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Krupka et al.

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(45) **Date of Patent: Oct. 11, 2016**

(54) **RANKING CLUSTERS BASED ON FACIAL IMAGE ANALYSIS**

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(51) **Int. Cl.**

G06K 9/00	(2006.01)
G06F 17/30	(2006.01)

(52) **U.S. Cl.**
CPC ***G06K 9/00677*** (2013.01); ***G06F 17/30259*** (2013.01); *G06K 2209/27* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,533,140	A	7/1996	Sirat et al.
6,108,437	A	8/2000	Lin
6,606,411	B1	8/2003	Loui
6,708,167	B2	3/2004	Lee
6,819,783	B2	11/2004	Goldberg et al.
7,035,764	B2	4/2006	Rui
7,058,209	B2	6/2006	Chen
7,587,068	B1	9/2009	Steinberg
7,653,249	B2	1/2010	Loui

(Continued)

FOREIGN PATENT DOCUMENTS

CN	101523412	9/2009
KR	1020090073294 A	7/2009

(Continued)

OTHER PUBLICATIONS

Bradymedia, Free Face Recognition API, Face Recognition Software Apps for the masses-face.com, Twittweb, Mar. 24, 2009, pp. 1-14, available at http://twittweb.com/business+rumors+surroun-21247785.*

(Continued)

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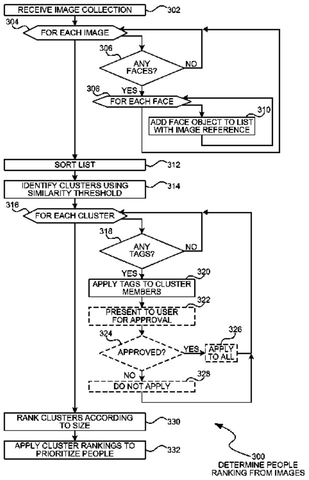
(74) *Attorney, Agent, or Firm* — Alin Corie; Sandy Swain; Micky Minhas

(57) **ABSTRACT**

A user's collection of images may be analyzed to identify people's faces within the images, then create clusters of similar faces, where each of the clusters may represent a person. The clusters may be ranked in order of size to determine a relative importance of the associated person to the user. The ranking may be used in many social networking applications to filter and present content that may be of interest to the user. In one use scenario, the clusters may be used to identify images from a second user's image collection, where the identified images may be pertinent or interesting to the first user. The ranking may also be a function of user interactions with the images, as well as other input not related to the images. The ranking may be incrementally updated when new images are added to the user's collection.

20 Claims, 12 Drawing Sheets


RECEIVE IMAGE COLLECTION
302
304
FOR EACH IMAGE
306
ANY FACES?
NO
YES
308
FOR EACH FACE
310
ADD FACE OBJECT TO LIST WITH IMAGE REFERENCE
SORT LIST
312
IDENTIFY CLUSTERS USING SIMILARITY THRESHOLD
314
316
FOR EACH CLUSTER
318
ANY TAGS?
NO
YES
320
APPLY TAGS TO CLUSTER MEMBERS
322
PRESENT TO USER FOR APPROVAL
324
APPROVED?
YES
326
APPLY TO ALL
NO
328
DO NOT APPLY
RANK CLUSTERS ACCORDING TO SIZE
330
APPLY CLUSTER RANKINGS TO PRIORITIZE PEOPLE
332
300
DETERMINE PEOPLE RANKING FROM IMAGES

(56) References Cited

U.S. PATENT DOCUMENTS

7,668,405	B2	2/2010	Gallagher	
7,783,085	B2 *	8/2010	Perlmutter	G06F 17/30256 382/118
8,189,880	B2 *	5/2012	Wen	G06F 17/30259 382/118
8,284,990	B2	10/2012	Ma et al.	
8,396,813	B2	3/2013	Gaucas et al.	
8,571,331	B2 *	10/2013	Cifarelli	G06F 17/3028 382/224
8,682,085	B2 *	3/2014	Isogai	G06F 17/30247 382/118
8,701,022	B2	4/2014	Sharpe et al.	
8,705,810	B2 *	4/2014	Wang	G06F 17/30781 382/103
2002/0143885	A1	10/2002	Ross, Jr.	
2002/0198936	A1	12/2002	McIntyre et al.	
2003/0128877	A1	7/2003	Nicponski	
2003/0202686	A1	10/2003	Rowe	
2003/0210808	A1 *	11/2003	Chen	G06K 9/00221 382/118
2004/0022442	A1 *	2/2004	Kim	382/225
2004/0101156	A1 *	5/2004	Kacker	G11B 27/031 382/100
2004/0197013	A1 *	10/2004	Kamei	382/118
2004/0264780	A1 *	12/2004	Zhang	G06F 17/30265 382/224
2005/0084154	A1 *	4/2005	Li	G06K 9/4652 382/190
2005/0105806	A1	5/2005	Nagaoka	
2005/0111737	A1 *	5/2005	Das	G06T 11/60 382/190
2005/0152619	A1	7/2005	Motomura et al.	
2005/0232495	A1 *	10/2005	Katoh et al.	382/225
2006/0048059	A1	3/2006	Etkin	
2006/0061598	A1 *	3/2006	Mino	G06K 9/00228 345/629
2006/0078201	A1 *	4/2006	Kim	G06F 17/30256 382/181
2006/0140455	A1 *	6/2006	Costache et al.	382/118
2006/0204058	A1 *	9/2006	Kim	G06K 9/00288 382/118
2006/0251292	A1 *	11/2006	Gokturk	G06F 17/30253 382/103
2006/0253491	A1 *	11/2006	Gokturk et al.	707/104.1
2007/0172155	A1	7/2007	Guckenberger	
2007/0173956	A1	7/2007	Koch et al.	
2007/0216709	A1	9/2007	Kojima et al.	
2007/0230799	A1 *	10/2007	Shniberg	G06F 17/30259 382/224
2007/0237355	A1	10/2007	Song et al.	
2007/0237364	A1	10/2007	Song	
2007/0239683	A1 *	10/2007	Gallagher	G06F 17/30265
2007/0239778	A1	10/2007	Gallagher	
2007/0244634	A1	10/2007	Koch et al.	
2007/0250476	A1	10/2007	Krasnik	
2007/0250532	A1 *	10/2007	Beato	G06F 17/30265
2007/0288305	A1 *	12/2007	Ozawa	G06Q 30/0201 705/7.29
2008/0080745	A1	4/2008	Vanhoucke et al.	
2008/0089561	A1 *	4/2008	Zhang	G06F 17/30259 382/118
2008/0140650	A1 *	6/2008	Stackpole	G06F 17/3087
2008/0192991	A1	8/2008	Gremse et al.	
2008/0208847	A1 *	8/2008	Moerchen et al.	707/5
2008/0226174	A1	9/2008	Hua	
2008/0270425	A1 *	10/2008	Cotgreave	G06F 17/30247
2008/0298643	A1	12/2008	Lawther et al.	
2008/0298766	A1	12/2008	Wen et al.	
2009/0034805	A1 *	2/2009	Perlmutter	G06F 17/30256 382/118
2009/0041299	A1	2/2009	Afzulpurkar	
2009/0180671	A1	7/2009	Lee	
2009/0196510	A1	8/2009	Gokturk et al.	
2009/0238419	A1	9/2009	Steinberg et al.	
2009/0252383	A1 *	10/2009	Adam	G06K 9/00221 382/118
2009/0252435	A1 *	10/2009	Wen	G06K 9/00228 382/284
2009/0254537	A1 *	10/2009	Yoshio	G06F 17/30256
2009/0279794	A1	11/2009	Brucher et al.	
2009/0292549	A1	11/2009	Ma et al.	
2010/0014721	A1	1/2010	Steinberg	
2010/0172550	A1 *	7/2010	Gilley	G06F 17/30259 382/118
2010/0177234	A1	7/2010	Ogura	
2010/0232656	A1	9/2010	Ryu	
2010/0250727	A1	9/2010	King et al.	
2010/0271395	A1 *	10/2010	Isogai	G06F 17/30247 345/635
2010/0274816	A1	10/2010	Guzik	
2010/0277611	A1	11/2010	Holt	
2010/0287053	A1	11/2010	Ganong	
2011/0029510	A1 *	2/2011	Kroon et al.	707/723
2011/0040756	A1	2/2011	Jones et al.	
2011/0148857	A1	6/2011	Krupka	
2011/0182482	A1 *	7/2011	Winters	G06F 17/30256 382/116
2011/0211737	A1	9/2011	Krupka	
2011/0211764	A1	9/2011	Krupka	
2011/0273592	A1	11/2011	Yamaoka et al.	

FOREIGN PATENT DOCUMENTS

WO	2009082814	A1	7/2009
WO	2009/128021		10/2009

OTHER PUBLICATIONS

Face.com, Wikipedia, pp. 1-3, available at http://en.wikipedia.org/wiki/Face.com.*

Facebook 101 How to Manual, Grand Valley State University, 2009, pp. 1-32.*

Roi Carthy, Face.com Brings Facial Recognition to Facebook Photos (We Have Invites), Tech Crunch, Mar. 24, 2009; pp. 1-6, available at http://techcrunch.com/2009/03/24/facecom-brings-facial-recognition-to-facebook-photos-we-have-invites/.*

Roi Carthy, It's Bulk Facebook Photo Tagging Time with Face.com Photo Tagger (Invites), Tech Crunch, Jul. 21, 2009; pp. 1-6, available at http://techcrunch.com/2009/07/21/its-facebook-photo-tagging-time-with-facecom-photo-tagger/.*

Kristen Nicole, Photo Tagger Automatically Tags Your Facebook Photos, AllFacebook, Jul. 21, 2009, pp. 1-5, available at http://allfacebook.com/photo-tagger_b6803.*

EasyAlbum—Re-ranking, Cui et al., ACM, 1-59593-178, 2007, pp. 367-376.*

"International Search Report", Mailed Date: Sep. 28, 2011, Application No. PCT/US2011/026356, Filed Date: Feb. 25, 2011, pp. 9.

"Tag4you", Retrieved at <<http://www.tag4you.com/>> 2007, p. 1.

"Major Photo Opportunity", Retrieved at <<http://www.apple.com/ilife/iphoto/>> 2009, pp. 4.

"Beyond Photo Tagging: Face Recognition", Retrieved at <<http://www.newmediapower.com/blog/beyond-photo-tagging-face-recognition/>> Mar. 28, 2009.

Hua, G et al.; "A Robust Elastic and Partial Matching Metric for Face Recognition"; IEEE 12th International Conference on Computer Vision; Sep. 29, 2009-Oct. 2, 2009; pp. 2082-2089.

Damaster, "Microsoft OneAlbum: Fusing Facial Recognition and Social Networks—The Future of Windows Live Photos?", LiveSide, Mar. 4, 2010.

Eldon, "Find Untagged Photos of your Facebook Friends with Face.com's Photo Finder", VentureBeat, Mar. 24, 2009.

Krupka, "Social Network System with Recommendations", U.S. Appl. No. 61/309,059, filed Mar. 1, 2010.

Lai, "Design and Implementation of an Online Social Network with Face Recognition", Journal of Advances in Information Technology, Feb. 2010.

Shankland, "Revamped Google Picasa Site Identifies Photo Faces", Underexposed, Sep. 2, 2008.

(56) **References Cited**

OTHER PUBLICATIONS

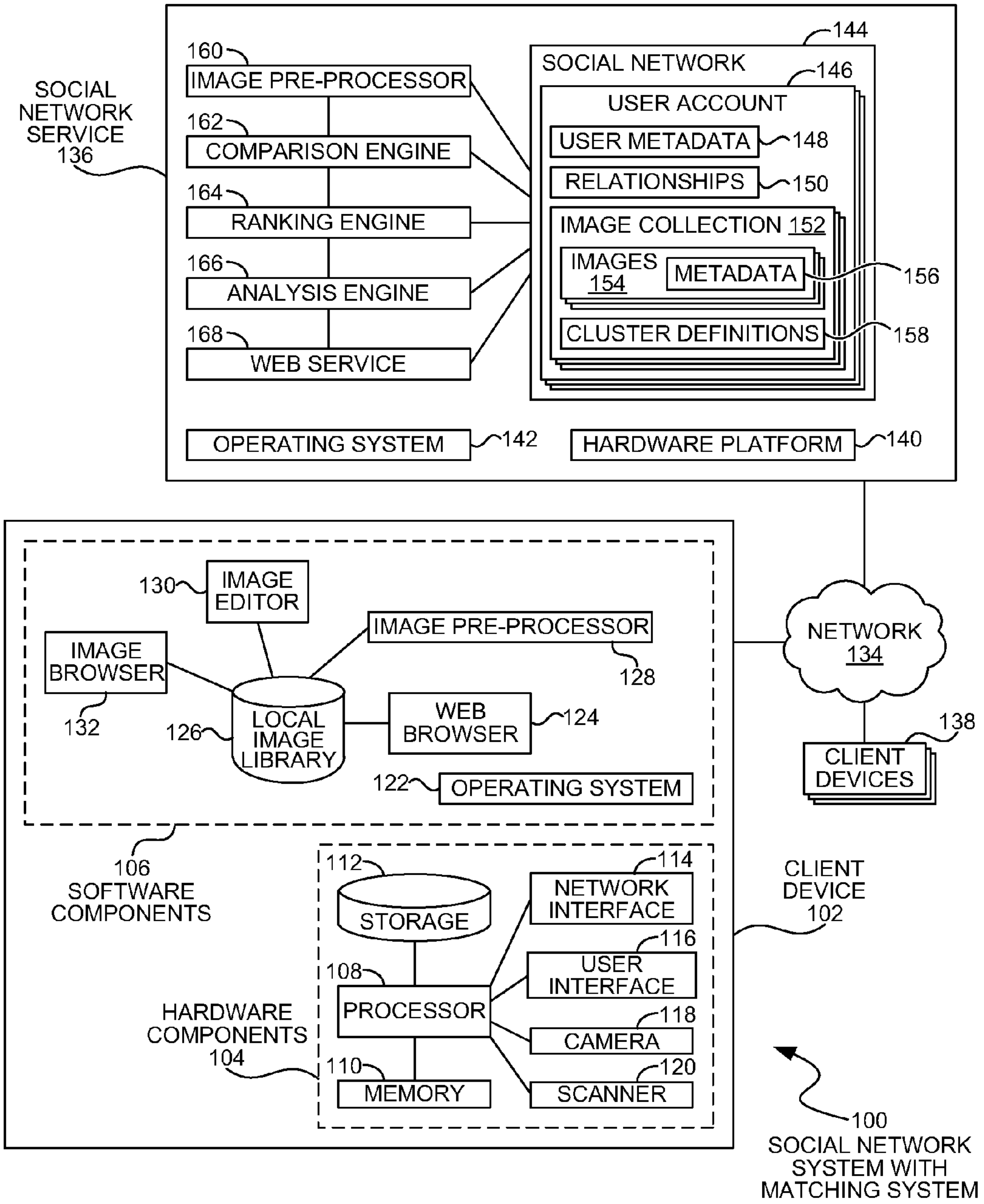
Gong, "Segmenting Photo Streams in Events Based on Optical Metadata", Proceedings of the International Conference on Semantic Computing, Sep. 17-19, 2007.
"iphoto'09" Retrieved at << http://www.apple.com/ilife/iphoto/ >>, Retrieved Feb. 20, 2010.
Krupka, "Event Matching in Social Networks", U.S. Appl. No. 61/309,032, filed Mar. 1, 2010.
Loui, "Automatic Image Event Segmentation and Quality Screening for Albuming Applications", Proceedings of the IEEE International Conference on Multimedia and Expo, Jul. 2000.
Zhao, "Automatic Person Annotation of Family Photo Album", Proceedings of the 5th International Conference on Image and Video Retrieval, Jul. 13-15, 2006.
CN 201180011712.8 Filed Feb. 25, 2011 by Applicant Microsoft Corporation , Second Office Action Dated Jan. 6, 2014, 13 Pages.
Ahonen, "Face Recognition with Local Binary Patterns", Proceedings of the 8th European Conference on Computer Vision, May 11-14, 2004.
Belhumeur, "Eigenfaces vs. Fisherfaces: Recognition Using Class Specific Linear Projection", IEEE Transactions on Pattern Analysis and Machine Intelligence, Jul. 1997.
Cai, "Orthogonal Laplacianfaces for Face Recognition", IEEE Transactions on Image Processing, Nov. 2006.
Cai, "Learning a Spatially Smooth Subspace for Face Recognition", IEEE Computer Society Conference on Computer Vision and Pattern Recognition, Jun. 2007.
Cai, "Spectral Regression for Efficient Regularized Subspace Learning", Proceedings of the IEEE International Conference on Computer Vision, Oct. 2007.
CN Notice on the First Office Action for Application No. 201180011712.8, May 6, 2013.
Gao, "Face Recognition Using Line Edge Map", IEEE Transactions on Pattern Analysis and Machine Intelligence, Jun. 2002.
Georghiades, "From Few to Many: Illumination Cone Models for Face Recognition Under Variable Lighting and Pose", IEEE Transactions on Pattern Analysis and Machine Intelligence, Jun. 2001.
He, "Face Recognition Using Laplacianfaces", IEEE Transactions on Pattern Analysis and Machine Intelligence, Mar. 2005.
Hua, "Discriminant Embedding for Local Image Descriptors", 11th International Conference on Computer Vision, Oct. 14-21, 2007.
Huang, "Labeled Faces in the Wild: A Database for Studying Face Recognition in unconstrained Environments", Oct. 2007.
Huang, "LFW Results Using a Combined Nowak Plus Merl Recognizer", Workshop on Faces in Real-Life Images: Detection, Alignment, and Recognition, Oct. 2008.
Krupka, "Ranking Based on Facial Image Analysis", U.S. Appl. No. 61/309,029, filed Mar. 1, 2010.
Liang, "Face Alignment Via Component-Based Discriminative Search", 10th European Conference on Computer Vision, Oct. 12-18, 2008.
Lowe, "Distinctive Image Features from Scale-Invariant Keypoints", International Journal of Computer Vision, Jan. 5, 2004.
Lucey, "Learning Patch Dependencies from Improved Pose Mismatched Face Verification", IEEE Computer Society Conference on Computer Vision and Pattern Recognition, Jun. 17-22, 2006.
Luo, "Person-Specific Sift Features for Face Recognition", International Conference on Acoustics, Speech and Signal Processing, Apr. 15-20, 2007.
Moghaddam, "Bayesian Face Recognition", Pattern Recognition, Nov. 2000.
Nowak, "Learning Visual Similarity Measures for Comparing Never Seen Objects", Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, Jun. 18-23, 2007.
Phillips, "Overview of the Face Recognition Grand Challenge", Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, Jun. 20-25, 2005.
Samaria, "Parameterisation of a Stochastic Model for Human Face Identification", Proceedings of the 2nd IEEE Workshop on Applications of Computer Vision, Dec. 1994.
Sim, "The CMU Pose, Illumination, and Expression Database", IEEE Transactions on Pattern Analysis and Machine Intelligence, Jan. 2003.
Takacs, "Comparing Face Images Using the Modified Hausdorff Distance", Pattern Recognition, Dec. 1998.
Tola, "A Fast Local Descriptor for Dense Matching", Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, Jun. 23-28, 2008.
Turk, "Face Recognition Using Eigenfaces", Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, Jun. 3-6, 1991.
Viola, "Robust Real-Time Face Detection", International Journal of Computer Vision, May 2004.
Vivek, "Robust Hausdorff Distance Measure for Face Recognition", Pattern Recognition, Feb. 2007.
Wang, "Generalized Quotient Image", Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, Jun. 27-Jul. 2, 2004.
Winder, "Learning Local Image Descriptors", Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, Jun. 17-22, 2007.
Wiskott, "Face Recognition by Elastic Bunch Graph Matching", IEEE Transactions on Pattern Analysis and Machine Intelligence, Jul. 1997.
Wolf, "Descriptor Based Methods in the Wild", Faces in Real-Life Images Workshop in European Conference on Computer Vision, Oct. 17, 2008.
Wright, "Implicit Elastic Matching with Random Projections for Pose-Variant Face Recognition", Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, Jun. 20-25, 2009.
Zhang, "Multiple-Instance Pruning for Learning Efficient Cascade Detectors", 21st Annual Conference on Neural Information Processing Systems, Dec. 3-5, 2007.
"Third Office Action Issued in Chinese Patent Application No. 201180011712.8", Mailed Date: Jul. 14, 2014, 7 Pages.
"Response to the Third Office Action Issued in Chinese Patent Application No. 201180011712.8", Mailed Date: Sep. 26, 2014.
"Response to the Second Office Action Issued in Chinese Patent Application No. 201180011712.8", Mailed Date: Mar. 14, 2014.
"Response to the First Office Action Issued in Chinese Patent Application No. 201180011712.8", Mailed Date: Sep. 5, 2013.
Girgensohn, et al., "Leveraging Face Recognition Technology to Find and Organize Photos", Retrieved at << http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.95.2060&rep=rep1&type=pdf >>, International Multimedia Conference, Proceedings of the 6th ACM SIGMM international workshop on Multimedia information retrieval, Oct. 15-16, 2004, pp. 8.
Zhang, et al., "Bayesian Face Annotation in Family Albums", Retrieved at << http://research.microsoft.com/en-us/um/people/leizhang/paper/iccv03demo.pdf >>, ICCV, 2003, pp. 2.
Fourth Office Action mailed Feb. 2, 2015 from China Patent Application No. 201180011712.8, 7 pages.
Non-Final Office Action mailed Oct. 2, 2012 from U.S. Appl. No. 12/784,500, 18 pages.
Amendment/Response filed Jan. 2, 2013 to Non-Final Office Action mailed Oct. 2, 2012 from U.S. Appl. No. 12/784,500, 11 pages.
Final Office Action mailed Jan. 23, 2013 from U.S. Appl. No. 12/784,500,19 pages.
Amendment/Response filed Apr. 22, 2013 to Final Office Action mailed Jan. 23, 2013 from U.S. Appl. No. 12/784,500, 12 pages.
Non-Final Office Action mailed May 13, 2014 from U.S. Appl. No. 12/784,500,17 pages.
Amendment/Response filed Aug. 8, 2014 to Non-Final Office Action mailed May 13, 2014 from U.S. Appl. No. 12/784,500, 11 pages.
Notice of Allowance mailed Nov. 13, 2014 from U.S. Appl. No. 12/784,500, 11 pages.
Non-Final Office Action mailed Nov. 26, 2012 from U.S. Appl. No. 12/785,491, 24 pages.
Amendment/Response filed Feb. 25, 2013 to Non-Final Office Action mailed Nov. 26, 2012 from U.S. Appl. No. 12/785,491,10 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Final Office Action mailed May 30, 2013 from U.S. Appl. No. 12/785,491,15 pages.
Amendment/Response filed Aug. 28, 2013 to Final Office Action mailed May 30, 2013 from U.S. Appl. No. 12/785,491,10 pages.
Non-Final Office Action mailed Sep. 5, 2014 from U.S. Appl. No. 12/785,491, 19 pages.
Amendment/Response filed Dec. 5, 2014 to Non-Final Office Action mailed Sep. 5, 2014 from U.S. Appl. No. 12/785,491, 12 pages.
Final Office Action mailed Mar. 6, 2015 from U.S. Appl. No. 12/785,491, 18 pages.
RCE with Amendment/Response filed Jun. 11, 2015 to Final Office Action mailed Mar. 6, 2015 from U.S. Appl. No. 121785,491, 17 pages.
Non-Final Office Action mailed Jul. 16, 2015 from U.S. Appl. No. 12/785,491, 21 pages.
First Office Action and Search Report mailed Nov. 27, 2014 from China Patent Application No. 201110055060.X, 12 pages.
Preliminary Report on Patentability and Written Opinion mailed Sep. 4, 2012 from PCT Patent Application No. PCT/US2011/026356, 4 pages.
Stone et al., "Autotagging Facebook: Social Network Context Improves Photo Annotation," IEEE, 978-1-4244-2340-8, 2008, 8 pages.
Choi et al., "Face Annotation for Personal Photos Using Collaborative Face Recognition in Online Social Networks," IEEE, 978-1-4244-3298-1, 2009, 8 pages.
Moon, Wong, "Face recognition application on Facebook: Photo Tagger," Published on Jul. 22, 2009, retrieved at <<http://www.yeeyan.org/articles/view/11302/51257>> on Jan. 21, 2015, 2 pages.
Non-Final Office Action mailed Sep. 7, 2012 from U.S. Appl. No. 12/646,606, 10 pages.
Response filed Apr. 10, 2015 to Fourth Office Action mailed Feb. 2, 2015 from China Patent Application No. 201180011712.8, 15 pages.
Notice of Allowance mailed Jun. 4, 2015 from China Patent Application No. 201180011712.8, 8 pages.
Voluntary Amendment filed May 29, 2013 from China Patent Application No. 201110061369.X, 16 pages.
First Office Action and Search Report mailed Dec. 3, 2014 from China Patent Application No. 201110061369.X, 12 pages.
Response filed Apr. 20, 2015 to First Office Action and Search Report mailed Dec. 3, 2014 from China Patent Application No. 201110061369.X, 16 pages.
Second Office Action and Search Report mailed Aug. 10, 2015 from China Patent Application No. 201110061369.X, 12 pages.
Response filed Mar. 31, 2015 to First Office Action and Search Report mailed Nov. 27, 2014 from China Patent Application No. 201110055060.X, 10 pages.
Second Office Action mailed May 21, 2015 from China Patent Application No. 201110055060.X, 9 pages.
Response filed Jul. 22, 2015 to Second Office Action mailed May 21, 2015 from China Patent Application No. 201110055060.X, 9 pages.
Third Office Action mailed Sep. 18, 2015 from China Patent Application No. 201110055060.X, 10 pages.
Response filed Oct. 15, 2015 to the Non-Final Office Action mailed Jul. 16, 2015 from U.S. Appl. No. 12/785,491, 19 pages.
Final Office Action mailed Jan. 15, 2016 from U.S. Appl. No. 12/785,491, 29 pages.
Response filed Dec. 1, 2015 to the Third Office Action mailed Sep. 18, 2015 from China Patent Application No. 201110055060.x, 11 pages.
Amendment filed Feb. 25, 2016 in view of Examiner Interview from China Patent Application No. 201110055060.X, 8 pages.
Response filed Oct. 26, 2015 to the Second Office Action mailed Aug. 10, 2015 from China Patent Application No. 201110061369.X, 7 pages.
Third Office Action mailed Dec. 28, 2015 from China Patent Application No. 201110061369.X, 6 pages.
Response filed Mar. 13, 2016 from China Patent Application No. 201111006139.X, 10 pages.
Notice on Grant mailed Mar. 28, 2016 from China Patent Application No. 201110055060.X, 4 pages.
Notice of Allowance mailed Jul. 7, 2016 from China Patent Application No. 201111006139.X, 6 pages.

* cited by examiner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160
IMAGE PRE-PROCESSOR
162
COMPARISON ENGINE
164
RANKING ENGINE
166
ANALYSIS ENGINE
168
WEB SERVICE
144
SOCIAL NETWORK
146
USER ACCOUNT
USER METADATA
148
RELATIONSHIPS
150
IMAGE COLLECTION 152
IMAGES 154
METADATA
156
CLUSTER DEFINITIONS
158
OPERATING SYSTEM
142
HARDWARE PLATFORM
140
130
IMAGE EDITOR
IMAGE BROWSER
132
IMAGE PRE-PROCESSOR
128
126
LOCAL IMAGE LIBRARY
WEB BROWSER
124
122
OPERATING SYSTEM
NETWORK 134
138
CLIENT DEVICES
106 SOFTWARE COMPONENTS
112
STORAGE
114
NETWORK INTERFACE
116
USER INTERFACE
108
PROCESSOR
118
CAMERA
HARDWARE COMPONENTS 104
110
MEMORY
120
SCANNER
CLIENT DEVICE 102
100
SOCIAL NETWORK SYSTEM WITH MATCHING SYSTEM

FIG. 1

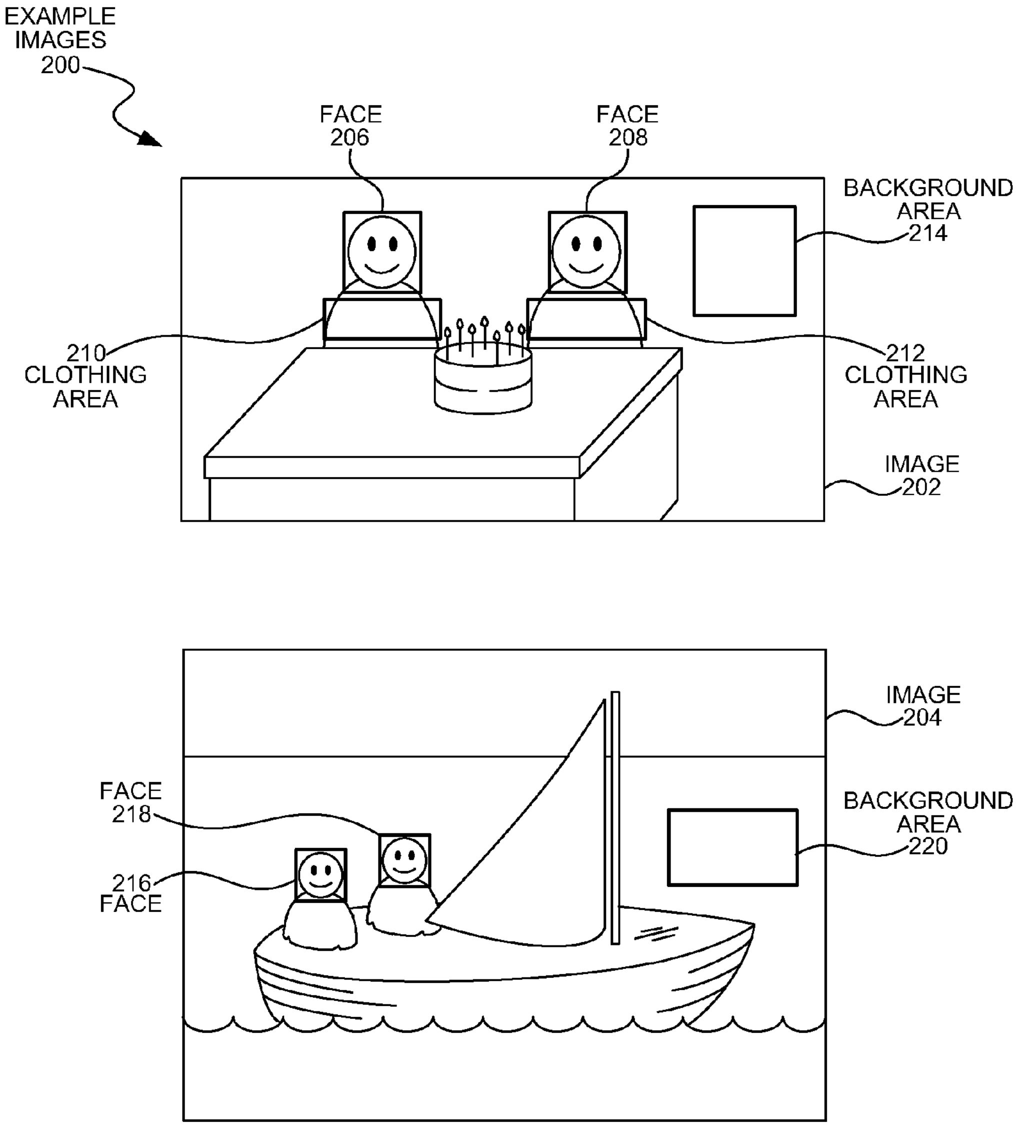
EXAMPLE IMAGES 200
FACE 206
FACE 208
BACKGROUND AREA 214
210 CLOTHING AREA
212 CLOTHING AREA
IMAGE 202
IMAGE 204
FACE 218
216 FACE
BACKGROUND AREA 220

FIG. 2

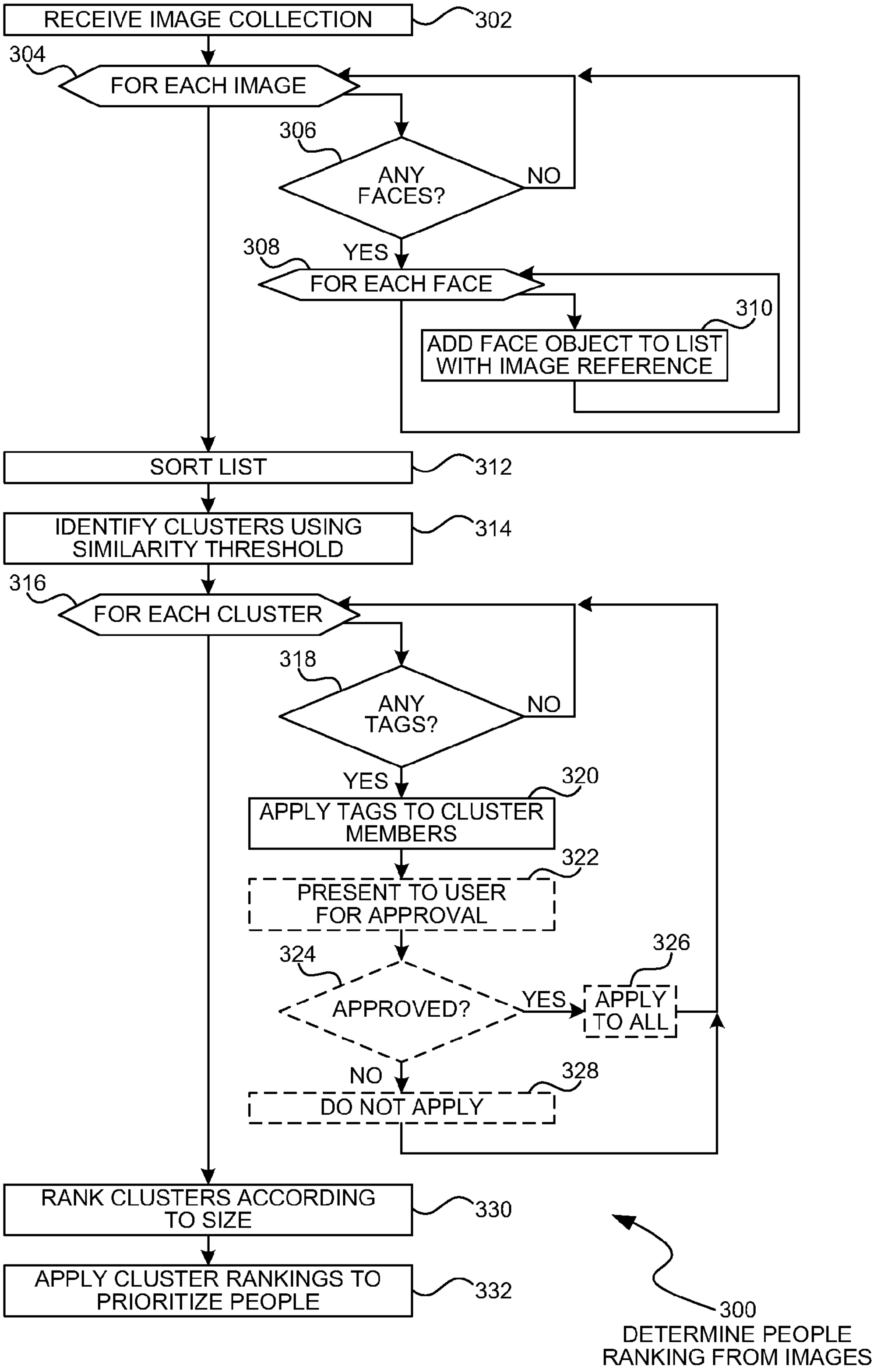
RECEIVE IMAGE COLLECTION
302
304
FOR EACH IMAGE
306
ANY FACES?
NO
308
YES
FOR EACH FACE
310
ADD FACE OBJECT TO LIST WITH IMAGE REFERENCE
SORT LIST
312
IDENTIFY CLUSTERS USING SIMILARITY THRESHOLD
314
316
FOR EACH CLUSTER
318
ANY TAGS?
NO
YES
320
APPLY TAGS TO CLUSTER MEMBERS
322
PRESENT TO USER FOR APPROVAL
324
APPROVED?
YES
326
APPLY TO ALL
NO
328
DO NOT APPLY
RANK CLUSTERS ACCORDING TO SIZE
330
APPLY CLUSTER RANKINGS TO PRIORITIZE PEOPLE
332
300
DETERMINE PEOPLE RANKING FROM IMAGES

FIG. 3

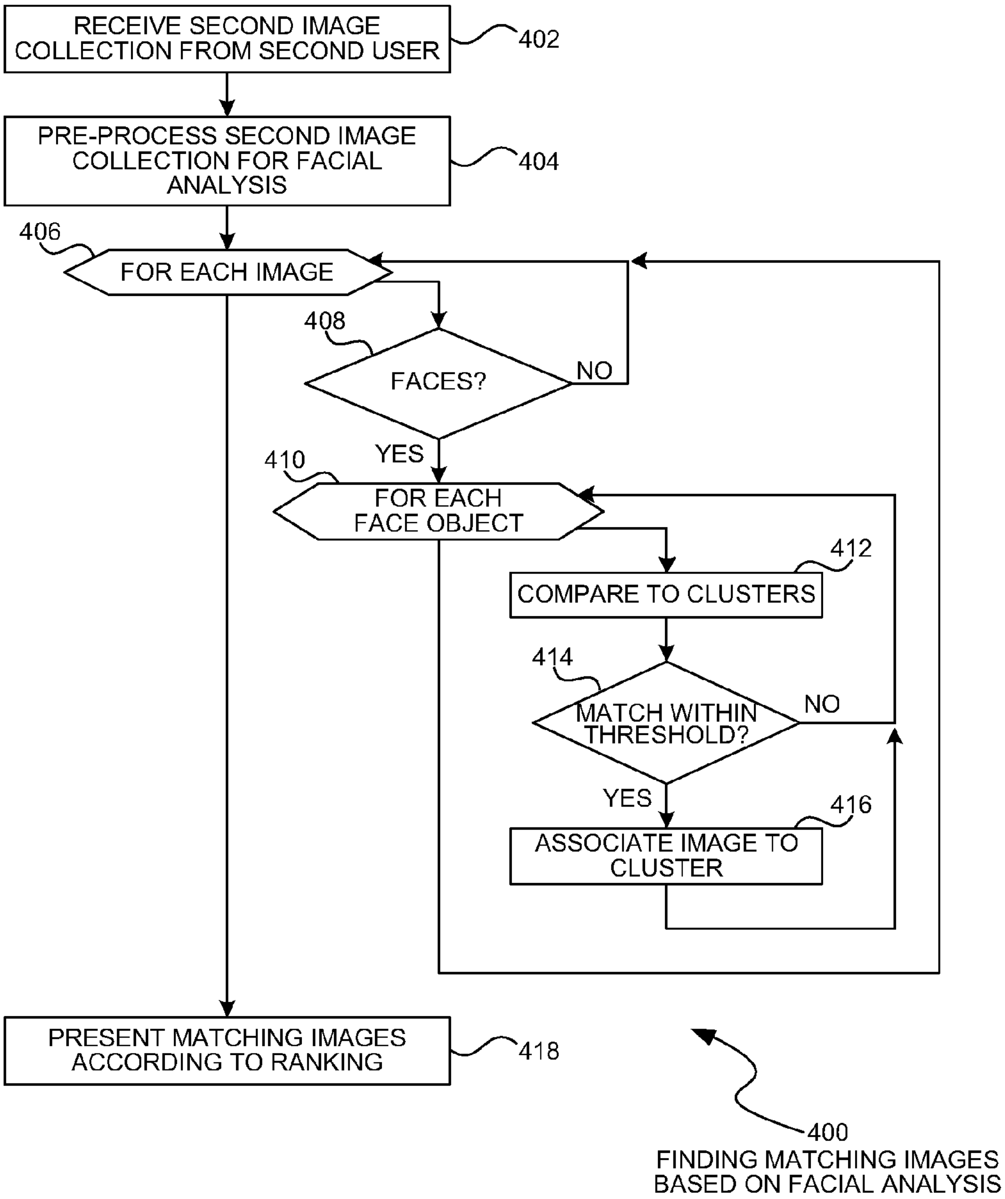
RECEIVE SECOND IMAGE COLLECTION FROM SECOND USER
402
PRE-PROCESS SECOND IMAGE COLLECTION FOR FACIAL ANALYSIS
404
406
FOR EACH IMAGE
408
FACES?
NO
YES
410
FOR EACH FACE OBJECT
412
COMPARE TO CLUSTERS
414
MATCH WITHIN THRESHOLD?
NO
YES
416
ASSOCIATE IMAGE TO CLUSTER
PRESENT MATCHING IMAGES ACCORDING TO RANKING
418
400
FINDING MATCHING IMAGES BASED ON FACIAL ANALYSIS

FIG. 4

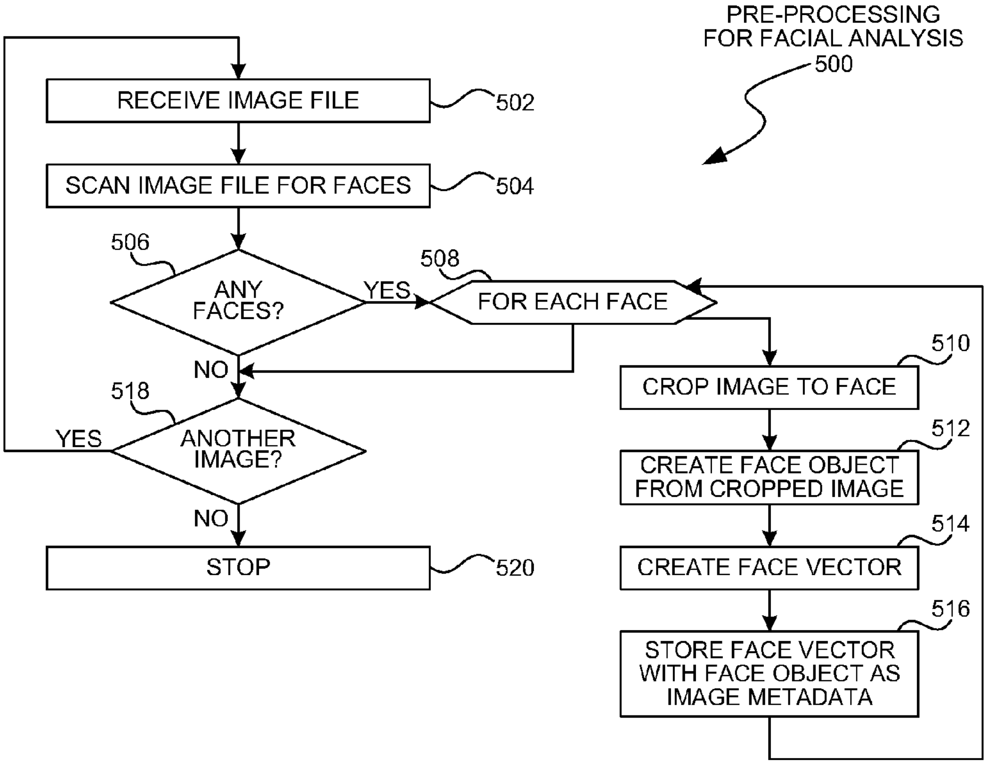
PRE-PROCESSING
FOR FACIAL ANALYSIS
500
RECEIVE IMAGE FILE
502
SCAN IMAGE FILE FOR FACES
504
506
ANY FACES?
YES
508
FOR EACH FACE
NO
510
CROP IMAGE TO FACE
512
CREATE FACE OBJECT FROM CROPPED IMAGE
514
CREATE FACE VECTOR
516
STORE FACE VECTOR WITH FACE OBJECT AS IMAGE METADATA
518
YES
ANOTHER IMAGE?
NO
STOP
520

FIG. 5

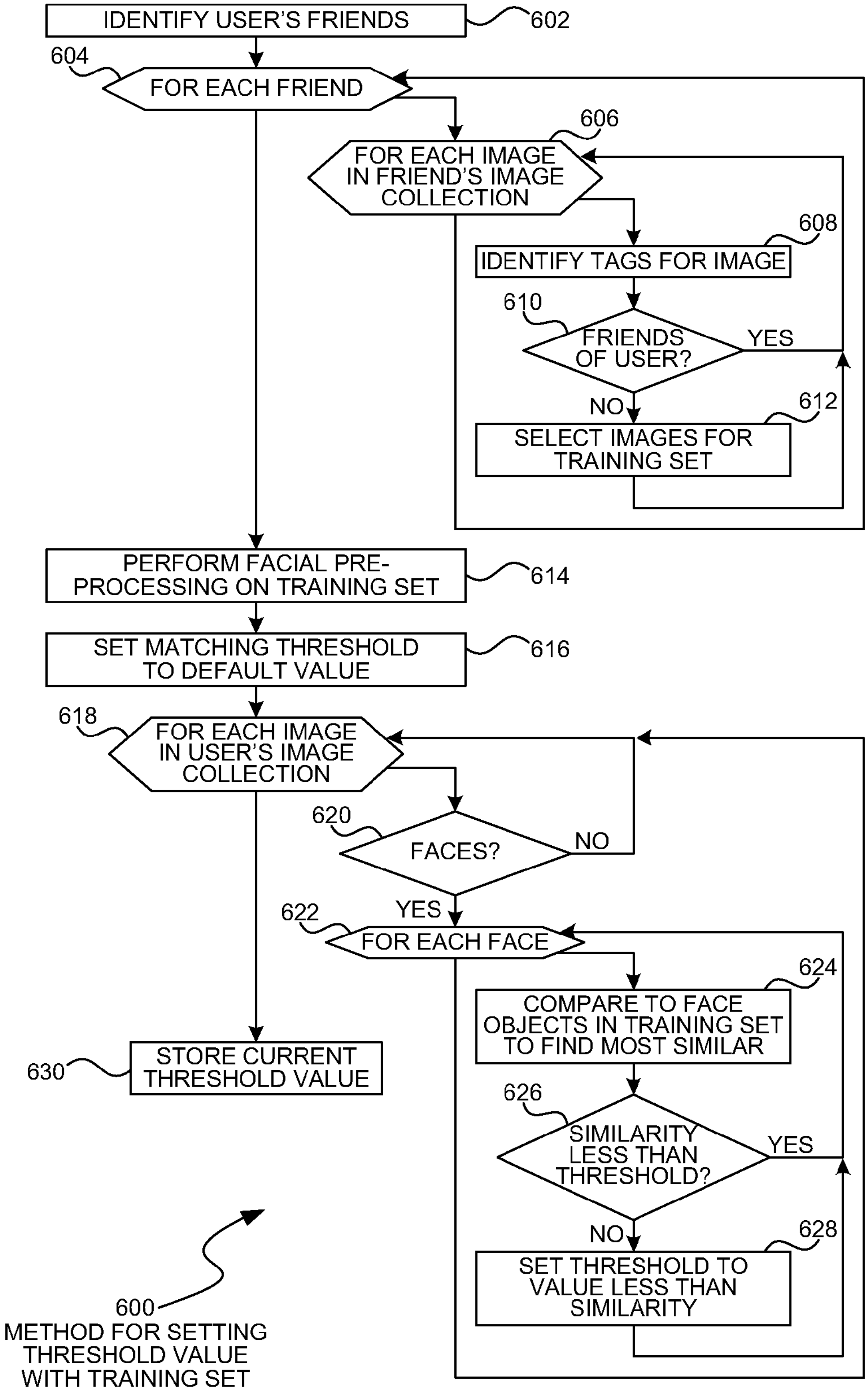
IDENTIFY USER'S FRIENDS
602
604
FOR EACH FRIEND
606
FOR EACH IMAGE IN FRIEND'S IMAGE COLLECTION
608
IDENTIFY TAGS FOR IMAGE
610
FRIENDS OF USER?
YES
NO
612
SELECT IMAGES FOR TRAINING SET
PERFORM FACIAL PRE-PROCESSING ON TRAINING SET
614
SET MATCHING THRESHOLD TO DEFAULT VALUE
616
618
FOR EACH IMAGE IN USER'S IMAGE COLLECTION
620
FACES?
NO
622
YES
FOR EACH FACE
624
COMPARE TO FACE OBJECTS IN TRAINING SET TO FIND MOST SIMILAR
630
STORE CURRENT THRESHOLD VALUE
626
SIMILARITY LESS THAN THRESHOLD?
YES
NO
628
SET THRESHOLD TO VALUE LESS THAN SIMILARITY
600
METHOD FOR SETTING THRESHOLD VALUE WITH TRAINING SET

FIG. 6

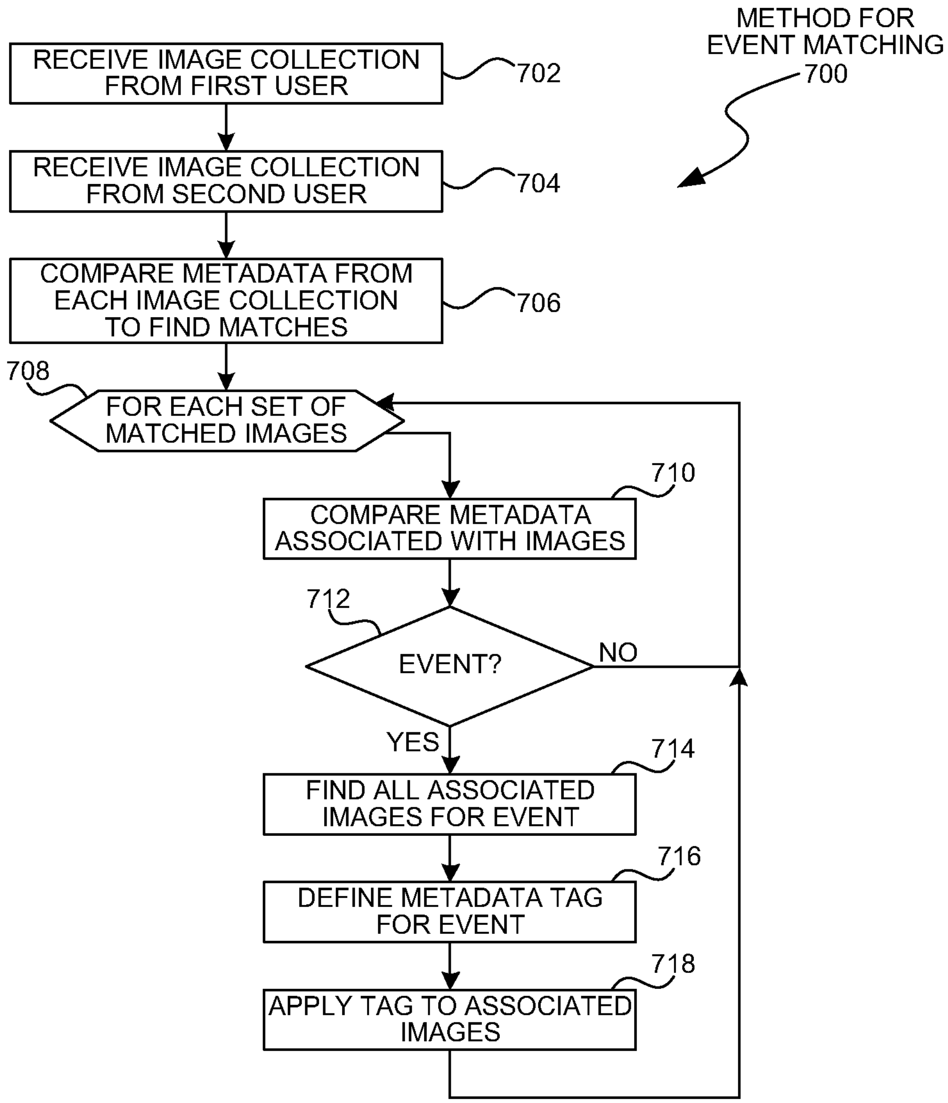
METHOD FOR EVENT MATCHING
700
RECEIVE IMAGE COLLECTION FROM FIRST USER
702
RECEIVE IMAGE COLLECTION FROM SECOND USER
704
COMPARE METADATA FROM EACH IMAGE COLLECTION TO FIND MATCHES
706
708
FOR EACH SET OF MATCHED IMAGES
710
COMPARE METADATA ASSOCIATED WITH IMAGES
712
EVENT?
NO
YES
714
FIND ALL ASSOCIATED IMAGES FOR EVENT
716
DEFINE METADATA TAG FOR EVENT
718
APPLY TAG TO ASSOCIATED IMAGES

FIG. 7

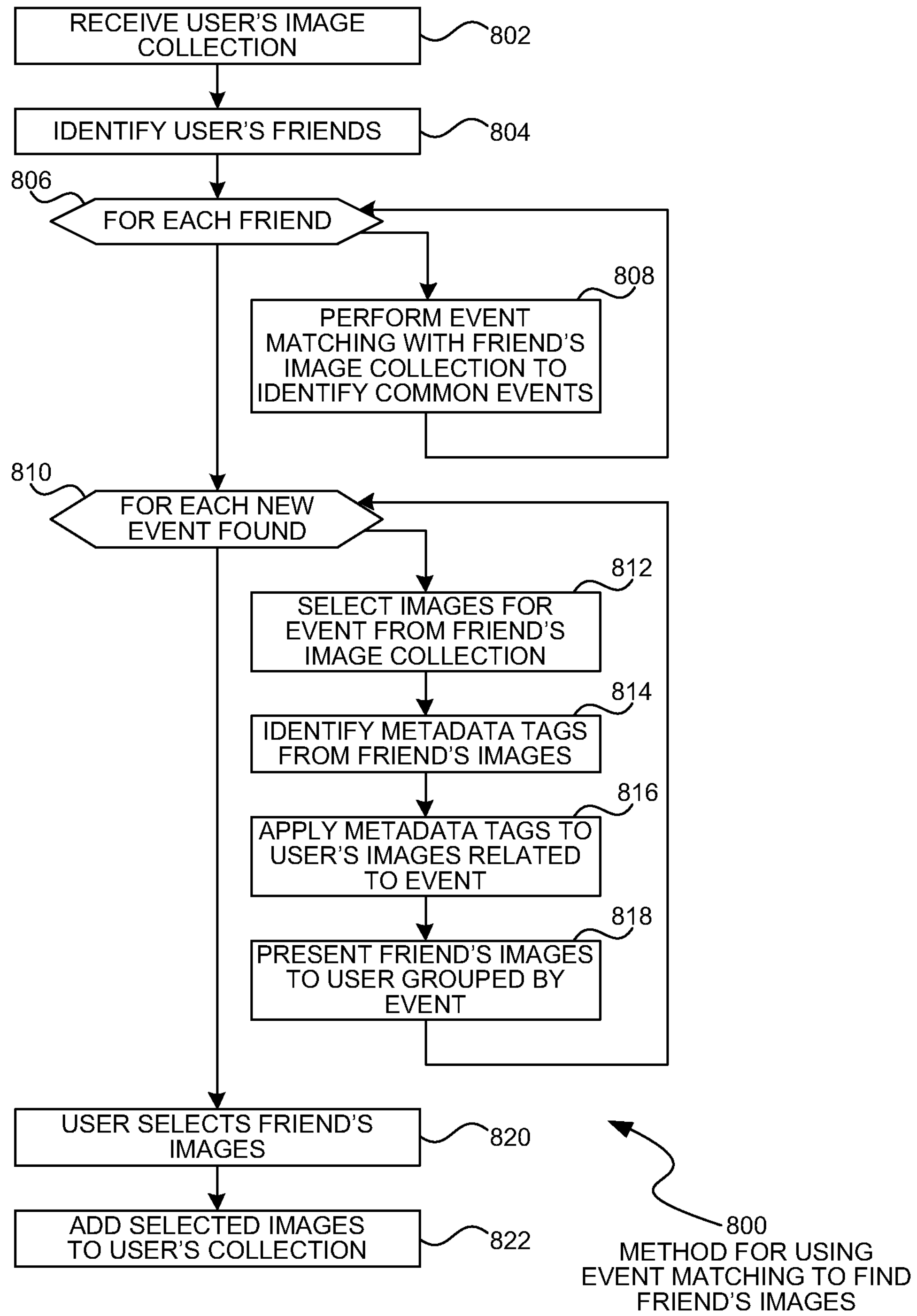
RECEIVE USER'S IMAGE COLLECTION
802
IDENTIFY USER'S FRIENDS
804
806
FOR EACH FRIEND
808
PERFORM EVENT MATCHING WITH FRIEND'S IMAGE COLLECTION TO IDENTIFY COMMON EVENTS
810
FOR EACH NEW EVENT FOUND
812
SELECT IMAGES FOR EVENT FROM FRIEND'S IMAGE COLLECTION
814
IDENTIFY METADATA TAGS FROM FRIEND'S IMAGES
816
APPLY METADATA TAGS TO USER'S IMAGES RELATED TO EVENT
818
PRESENT FRIEND'S IMAGES TO USER GROUPED BY EVENT
USER SELECTS FRIEND'S IMAGES
820
ADD SELECTED IMAGES TO USER'S COLLECTION
822
800
METHOD FOR USING EVENT MATCHING TO FIND FRIEND'S IMAGES

FIG. 8

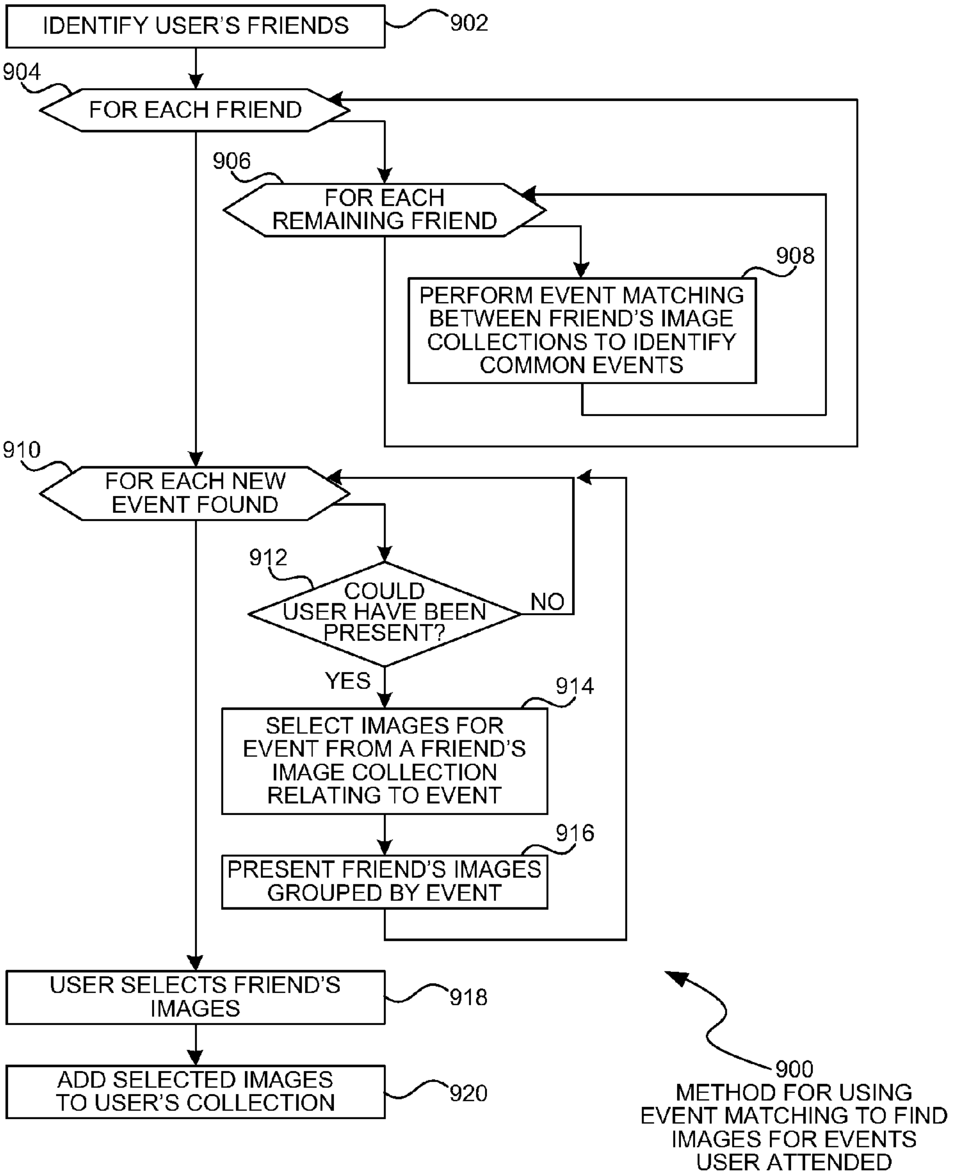
IDENTIFY USER'S FRIENDS
902
904
FOR EACH FRIEND
906
FOR EACH REMAINING FRIEND
908
PERFORM EVENT MATCHING BETWEEN FRIEND'S IMAGE COLLECTIONS TO IDENTIFY COMMON EVENTS
910
FOR EACH NEW EVENT FOUND
912
COULD USER HAVE BEEN PRESENT?
NO
YES
914
SELECT IMAGES FOR EVENT FROM A FRIEND'S IMAGE COLLECTION RELATING TO EVENT
916
PRESENT FRIEND'S IMAGES GROUPED BY EVENT
USER SELECTS FRIEND'S IMAGES
918
ADD SELECTED IMAGES TO USER'S COLLECTION
920
900
METHOD FOR USING EVENT MATCHING TO FIND IMAGES FOR EVENTS USER ATTENDED

FIG. 9

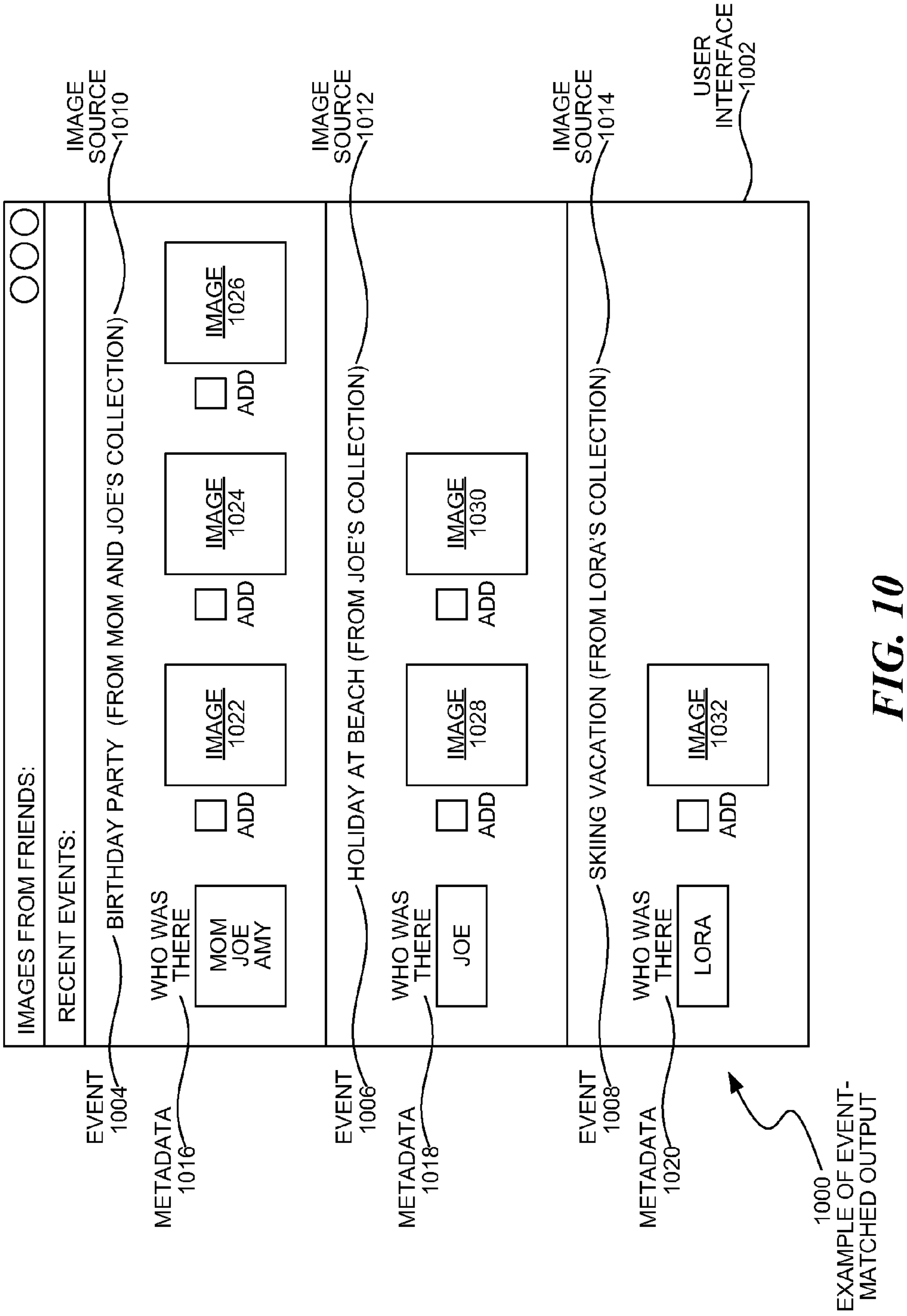
IMAGES FROM FRIENDS:
RECENT EVENTS:
BIRTHDAY PARTY (FROM MOM AND JOE'S COLLECTION)
WHO WAS THERE
MOM
JOE
AMY
ADD
IMAGE 1022
ADD
IMAGE 1024
ADD
IMAGE 1026
HOLIDAY AT BEACH (FROM JOE'S COLLECTION)
WHO WAS THERE
JOE
ADD
IMAGE 1028
ADD
IMAGE 1030
SKIING VACATION (FROM LORA'S COLLECTION)
WHO WAS THERE
LORA
ADD
IMAGE 1032
IMAGE SOURCE 1010
IMAGE SOURCE 1012
IMAGE SOURCE 1014
USER INTERFACE 1002
EVENT 1004
METADATA 1016
EVENT 1006
METADATA 1018
EVENT 1008
METADATA 1020
1000 EXAMPLE OF EVENT-MATCHED OUTPUT

FIG. 10

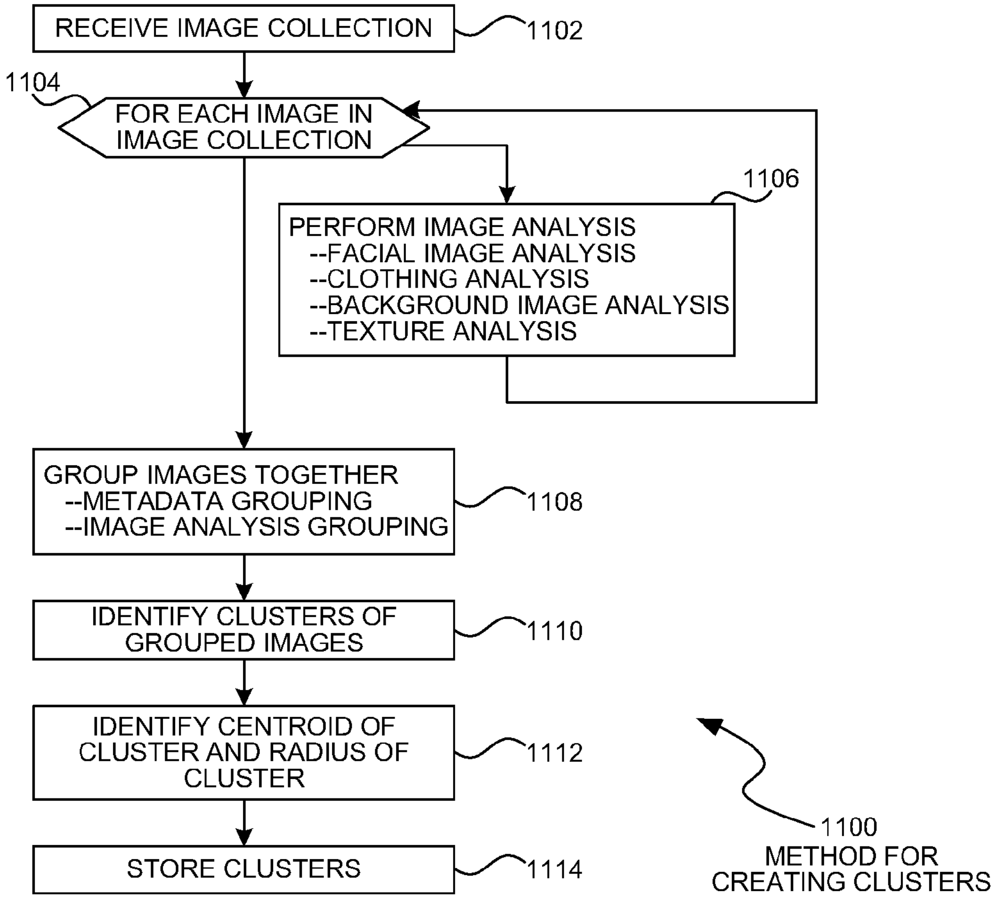
RECEIVE IMAGE COLLECTION
1102
1104
FOR EACH IMAGE IN IMAGE COLLECTION
1106
PERFORM IMAGE ANALYSIS
--FACIAL IMAGE ANALYSIS
--CLOTHING ANALYSIS
--BACKGROUND IMAGE ANALYSIS
--TEXTURE ANALYSIS
GROUP IMAGES TOGETHER
--METADATA GROUPING
--IMAGE ANALYSIS GROUPING
1108
IDENTIFY CLUSTERS OF GROUPED IMAGES
1110
IDENTIFY CENTROID OF CLUSTER AND RADIUS OF CLUSTER
1112
STORE CLUSTERS
1114
1100
METHOD FOR CREATING CLUSTERS

FIG. 11

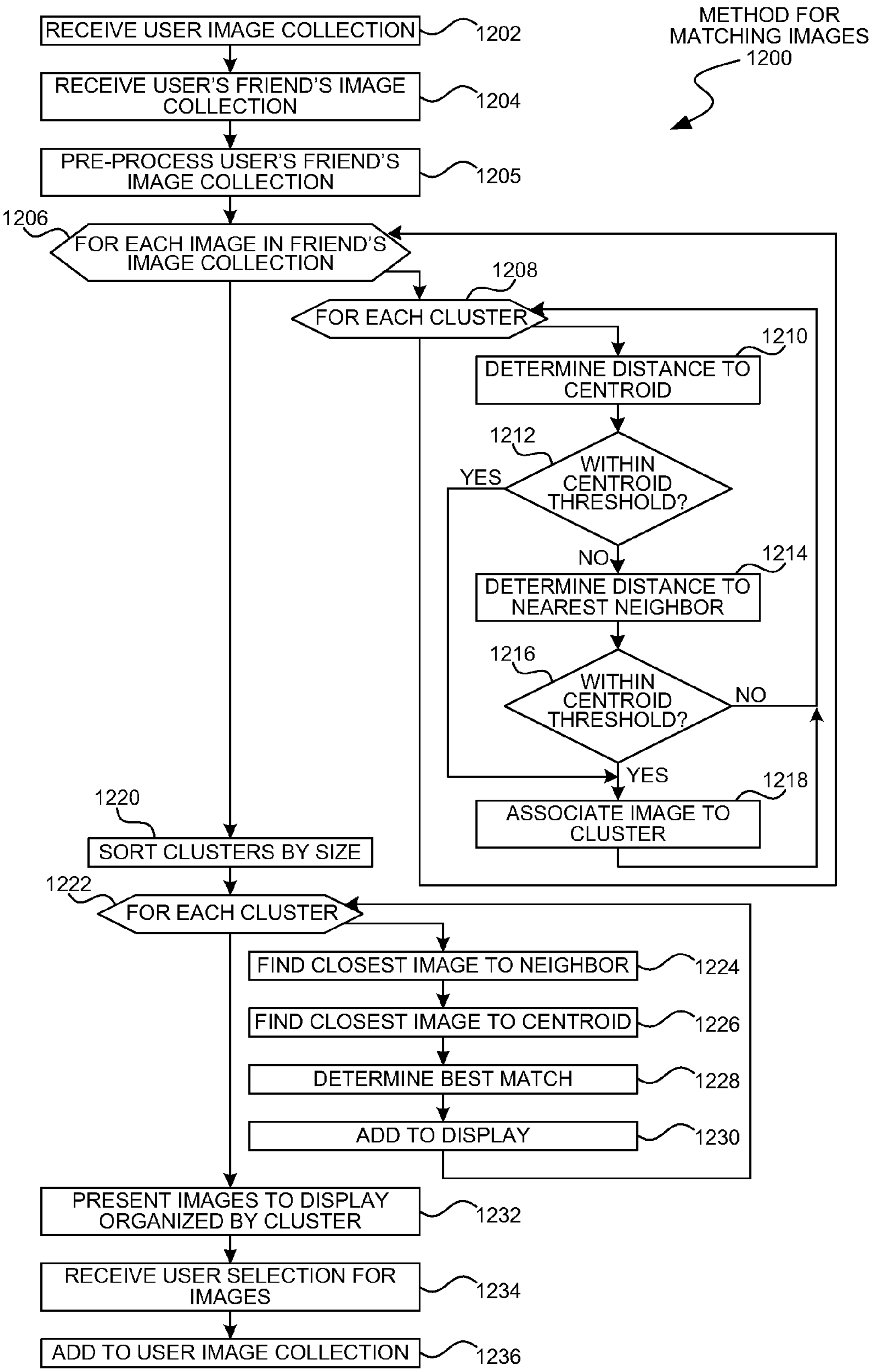
METHOD FOR MATCHING IMAGES
1200
RECEIVE USER IMAGE COLLECTION
1202
RECEIVE USER'S FRIEND'S IMAGE COLLECTION
1204
PRE-PROCESS USER'S FRIEND'S IMAGE COLLECTION
1205
1206
FOR EACH IMAGE IN FRIEND'S IMAGE COLLECTION
1208
FOR EACH CLUSTER
1210
DETERMINE DISTANCE TO CENTROID
1212
WITHIN CENTROID THRESHOLD?
YES
NO
1214
DETERMINE DISTANCE TO NEAREST NEIGHBOR
1216
WITHIN CENTROID THRESHOLD?
NO
YES
1218
ASSOCIATE IMAGE TO CLUSTER
1220
SORT CLUSTERS BY SIZE
1222
FOR EACH CLUSTER
FIND CLOSEST IMAGE TO NEIGHBOR
1224
FIND CLOSEST IMAGE TO CENTROID
1226
DETERMINE BEST MATCH
1228
ADD TO DISPLAY
1230
PRESENT IMAGES TO DISPLAY ORGANIZED BY CLUSTER
1232
RECEIVE USER SELECTION FOR IMAGES
1234
ADD TO USER IMAGE COLLECTION
1236

FIG. 12

RANKING CLUSTERS BASED ON FACIAL IMAGE ANALYSIS

CROSS REFERENCE TO RELATED APPLICATIONS

This patent application claims priority to and the benefit of U.S. Provisional Patent Application Ser. No. 61/309,029 entitled "Ranking Based on Facial Image Analysis" filed 1 Mar. 2010 by Eyal Krupka, et. al., the entire contents of which are hereby expressly incorporated by reference.

BACKGROUND

Image collections reflect important elements by the collection creator. For example, a user's personal image collection may be collected over an extended period of time and may reflect important elements in a person's life, such as important people. Many people may have image collections that include a wide range of images, from snapshots taken on a mobile telephone to composed images taken with a digital camera while on vacation, for example.

SUMMARY

A user's collection of images may be analyzed to identify people's faces within the images, then create clusters of similar faces, where each of the clusters may represent a person. The clusters may be ranked in order of size to determine a relative importance of the associated person to the user. The ranking may be used in many social networking applications to filter and present content that may be of interest to the user. In one use scenario, the clusters may be used to identify images from a second user's image collection, where the identified images may be pertinent or interesting to the first user. The ranking may also be a function of user interactions with the images, as well as other input not related to the images. The ranking may be incrementally updated when new images are added to the user's collection.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings,

FIG. **1** is a diagram illustration of an embodiment showing an system with a social network and image matching system.

FIG. **2** is a diagram illustration of an example embodiment showing example images.

FIG. **3** is a flowchart illustration of an embodiment showing a method for determining people rankings from images.

FIG. **4** is a flowchart illustration of an embodiment showing a method for finding matching images based on facial analysis.

FIG. **5** is a flowchart illustration of an embodiment showing a method for pre-processing for facial analysis.

FIG. **6** is a flowchart illustration of an embodiment showing a method for setting a threshold value with a training set.

FIG. **7** is a flowchart illustration of an embodiment showing a method for event matching.

FIG. **8** is a flowchart illustration of an embodiment showing a method for using event matching to find friend's images.

FIG. **9** is a flowchart illustration of an embodiment showing a method for using event matching to find images for events a user attended.

FIG. **10** is a diagram illustration of an example embodiment showing a user interface with event-matched output.

FIG. **11** is a flowchart illustration of an embodiment showing a method for creating clusters.

FIG. **12** is a flowchart illustration of an embodiment showing a method for matching images using clusters.

DETAILED DESCRIPTION

Facial image analysis and comparison of a user's image collection may be used to rank a user's preferences or priorities relating to their friends or family. A user's image collection may reflect the user's interest, importance, or affection for people. The quantity of images of a particular person may be used as a proxy for the person's importance to a user.

The facial image analysis may be performed over an image collection to identify faces within the images and create facial objects, which may be stored as metadata for an image. The facial objects may be represented grouped together into clusters of faces. The size of the clusters may be used as a measure of the importance of the friend associated with the facial object.

The ranking determined from the facial image analysis may be used to present relevant information to the user. For example, newsfeeds or other information that relates to different users may be prioritized and presented to a user with the more relevant information in a more prominent position in a user interface.

Throughout this specification and claims, references to the term 'image' may include static images, such as photographs or digital still images, as well as video images or motion picture images. The concepts discussed for processing images may be adapted to either still or moving images and in some embodiments, both still and moving images may be used.

Throughout this specification, like reference numbers signify the same elements throughout the description of the figures.

When elements are referred to as being "connected" or "coupled," the elements can be directly connected or coupled together or one or more intervening elements may also be present. In contrast, when elements are referred to as being "directly connected" or "directly coupled," there are no intervening elements present.

The subject matter may be embodied as devices, systems, methods, and/or computer program products. Accordingly, some or all of the subject matter may be embodied in hardware and/or in software (including firmware, resident software, micro-code, state machines, gate arrays, etc.) Furthermore, the subject matter may take the form of a computer program product on a computer-usable or computer-readable storage medium having computer-usable or computer-readable program code embodied in the medium for use by or in connection with an instruction execution system. In the context of this document, a computer-usable or computer-readable medium may be any medium that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

The computer-usable or computer-readable medium may be for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. By way of example, and not limitation, computer-readable media may comprise computer storage media and communication media.

Computer storage media includes volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information such as computer-readable instructions, data structures, program modules, or other data. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and may be accessed by an instruction execution system. Note that the computer-usable or computer-readable medium can be paper or other suitable medium upon which the program is printed, as the program can be electronically captured via, for instance, optical scanning of the paper or other suitable medium, then compiled, interpreted, of otherwise processed in a suitable manner, if necessary, and then stored in a computer memory.

Communication media typically embodies computer-readable instructions, data structures, program modules or other data in a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media. The term "modulated data signal" can be defined as a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media. Combinations of any of the above-mentioned should also be included within the scope of computer-readable media.

When the subject matter is embodied in the general context of computer-executable instructions, the embodiment may comprise program modules, executed by one or more systems, computers, or other devices. Generally, program modules include routines, programs, objects, components, data structures, and the like, that perform particular tasks or implement particular abstract data types. Typically, the functionality of the program modules may be combined or distributed as desired in various embodiments.

FIG. **1** is a diagram of an embodiment **100**, showing a client and server components for a social network. Embodiment **100** is a simplified example of a network environment that may include a client device and a social network service accessed through a network.

The diagram of FIG. **1** illustrates functional components of a system. In some cases, the component may be a hardware component, a software component, or a combination of hardware and software. Some of the components may be application level software, while other components may be operating system level components. In some cases, the connection of one component to another may be a close connection where two or more components are operating on a single hardware platform. In other cases, the connections may be made over network connections spanning long distances. Each embodiment may use different hardware, software, and interconnection architectures to achieve the described functions.

Embodiment **100** illustrates an example of a social network in which a user may have collection of images. The social network may be a web application in which various users may establish accounts in the social network and may manage image collections within the social network. A service operating within the social network infrastructure may analyze and compare the image collections.

The social network of embodiment **100** may be any type of social network in which express or implied relationships may exist between users. In some social networks, the relationships may be expressed by one user formally establishing a relationship with another user. Some social network may establish a one-way relationship through such a relationship declaration, while other social networks may establish a relationship when both users approve the relationship.

Some social networks may have informal relationships between users. For example, an informal relationship may be established when two users exchange email messages, or when the users communicate using another mechanism. For example, a social network may be established for users who communicate in a chat room, instant messaging service, or other mechanism. In some cases, a person's list of contacts in an email system or a mobile telephone may be used as an implied relationship for the purposes of establishing a social network relationship.

In some social networks, a user may determine how images within their image collections may be shared. In some cases, a user may select images that may be sharable to friends for which a relationship exists. In other cases, a user may permit any user with which to share images.

The social network may be a formal social network in which each user may create an account to access the social network. In many such embodiments, the users may access the social network through a web browser, and the social network may be a web application. In many such embodiments, a user may upload images to create an image collection inside the social network environment.

In less formal versions of a social network, a user may store and manage an image collection on a personal computer or in repositories that are personally controlled or managed by the user. In such a social network, the user may identify various storage locations from which images may be shared with other people. In some such social network, the social network relationships may be maintained using infrastructure that may be merely an address exchange, forum, or other mechanism by which members may connect with each other.

The client device **102** may have a set of hardware components **104** and software components **106**. The client device **102** may represent any type of device that may communicate with a social network service **136**.

The hardware components **104** may represent a typical architecture of a computing device, such as a desktop or server computer. In some embodiments, the client device **102** may be a personal computer, game console, network appliance, interactive kiosk, or other device. The client device **102** may also be a portable device, such as a laptop computer, netbook computer, personal digital assistant, mobile telephone, or other mobile device.

The hardware components **104** may include a processor **108**, random access memory **110**, and nonvolatile storage **112**. The hardware components **104** may also include one or more network interfaces **114** and user interface devices **116**. In many cases, the client device **102** may include cameras **118** or scanners **120** that may capture images that may become part of a user's image collection.

The software components **106** may include an operating system **112** on which various applications may execute, such as a web browser **124**. In many social networking applications, a web browser **124** may be used to communicate with a social network service **136** to access a social network application. In other embodiments, a specialized client application may communicate with a social network service to provide a user interface. In some such embodiments, such a client application may perform many functions that may be described in the social network service **136**.

The client device **102** may have a local image library **126** that may include images that are collected from many different sources, such as a camera **118**, scanner **120**, or other devices that may have image capture capabilities. The local image library **126** may include images that are stored on other devices, such as a server within a local area network or within a cloud storage service, for example.

The client device **102** may have several applications that may allow a user to view and manage the local image library **126**. Example of such applications may be an image editor **130** and image browser **132**. In some cases, a client device may have several such applications.

The local image library **126** may include both still images and video images. In some embodiments, still images and video images may be stored in different libraries and may be accessed, edited, and manipulated with different applications.

In some embodiments, the client device **102** may have an image pre-processor **128**. The image pre-processor may analyze the image contents as well as various metadata associated with the image prior to associating the image with a social network. The pre-processing may perform facial image analysis, background analysis, color histograms, or other analyses on images available to the client. In other embodiments, some or all of the functions performed by the image pre-processor **128** may be performed by the social network service **136**. When an image pre-processor **128** is located on the client device **102**, a server device may be offloaded from performing such operations.

The client device **102** may connect to the social network service **136** through a network **134**. In some embodiments, the network **134** may be a wide area network, such as the Internet. In some embodiments, the network **134** may include a local area network which may be connected to a wide area network through a gateway or other device.

In some embodiments, the client device **102** may connect to the network **134** through a hard wired connection, such as an Ethernet connection, for example. In other embodiments, the client device **102** may connect to the network **134** through a wireless connection, such as a cellular telephone connection or other wireless connection.

Various users of the social network may connect using various client devices **138**.

The social network service **136** may operate on hardware platform **140**. The hardware platform **140** may be a single server device that has a hardware platform similar to the hardware components **104** of the client device **102**. In some embodiments, the hardware platform **140** may be a virtualized or cloud based hardware platform that operates on two or more hardware devices. In some embodiments, the hardware platform may be a large datacenter in which many hundreds or thousands of computer hardware platforms may be used.

The social network service **136** may operate within an operating system **142** in some embodiments. In embodiments that have cloud based execution environments, the notion of a separate operating system **142** may not exist.

The social network **144** may include multiple user accounts **146**. Each user account **146** may include metadata

148 relating to the account, as well as relationships **150** that may be established between two or more users.

The user account metadata **148** may include information about the user, such as the user's name, home address, location, as well as the user's likes and dislikes, education, and other relevant information. Some social networks may have emphasis on work related information, which may include items like work history, professional associations, or other job-related information. Other social networks may emphasize friends and family relationships where personal items may be emphasized. In some social networks, very large amounts of personal metadata **148** may be included, while other social networks may have very little amount of personal metadata **148**.

The relationships **150** may associate one user account to another. In some embodiments, the relationships may be one-way relationships, where a first user may share information with a second user but the second user may not reciprocate and may share no information or a limited amount of information with the first user. In other embodiments, the relationships may be two-way relationships where each user agrees to share information with each other.

In still other embodiments, a user may allow some or all of their information to be shared to anyone, including people who are not members of the social network. Some such embodiments may allow a user to identify a subset of information that may be shared to anyone, as well as subsets that may be shared with other members of the social network. Some embodiments may allow a user to define subsets that are shared with different groups of social network members.

Each user account **146** may include one or more image collections **152**. The image collections **152** may include images **154**. Each image **154** may include metadata **156**, which may be general metadata such as timestamp, location information, image size, title, and various tags. The tags may include identifiers for different social network members to which the image may relate.

In some embodiments, the image metadata **156** may contain metadata derived from the image contents. For example, a facial analysis may be performed to identify any faces within the image and to create a facial representation or facial vector. The facial representation may be used to compare with other images, for example. Other image contents that may be used to derive metadata may include texture analysis of background areas or a person's clothing, color histograms of the entire image or portions of the image, or other analyses.

The image metadata **156** may be used to create clusters **158**. The clusters **158** may be groupings of images or elements from images. For example, facial representations may be analyzed to identify clusters that contain similar facial representations. Similarly, clusters may be created by grouping image analysis results from background areas of the images.

In some embodiments, clusters **158** may be created by grouping images based on metadata. For example, several images that are taken during a certain time period may be grouped together as a cluster, or images that are tagged with the same tag parameter may form a cluster. Examples of uses clusters may be found in embodiments **1100** and **1200** presented later in this specification.

In some embodiments, the social network service **136** may include an image pre-processor **160** that may analyze images to derive image metadata. The image pre-processor **160** may be used for instances where a client device **102** may not have an image pre-processor **128** or when image pre-processing is not performed prior to analysis. An example of the pre-processing steps may be illustrated in embodiment **500** presented later in this specification.

A comparison engine **162** may compare two or more images using image analysis techniques or metadata analysis to determine the clusters **158**. An example of the operations of a comparison engine **162** may be found in portions of embodiment **400** presented later in this specification.

A ranking engine **164** may compare the various clusters **158** to extract information, such as the ranking or importance of the images or information attached to the images. An example of the operations of a ranking engine **164** may be found in embodiment **300** presented later in this specification.

An analysis engine **166** may analyze and compare image collections to identify matches between the image collections. The analysis engine **166** may use metadata analysis and image content analysis to identify matches.

In many embodiments, a social network service **136** may operate with a web service **168** that may communicate with browsers or other applications operable on a client device. The web service **168** may receive requests in Hyper Text Transmission Protocol (HTTP) and respond with web pages or other HTTP compliant responses. In some embodiments, the web service **168** may have an application programming interface (API) through which an application on a client device may interact with the social network service.

FIG. **2** is a diagram of an example embodiment **200**, showing two images that may be analyzed by image analysis. Embodiment **200** illustrates two images **202** and **204** that show a birthday party and a sailing excursion, respectively. The images may represent example images that may be found in a user's image collection.

Image **202** may represent a birthday party with two people. From the image **202**, two faces **206** and **208** may be identified. Several different facial recognition mechanisms or algorithms may be used to identify the faces **206** and **208**.

Once identified, the faces **206** and **208** may be processed to create representations of the faces. The representations may be facial vectors or other representations that may allow numerical comparisons of different faces to each other.

In some embodiments, additional image analyses may be performed. For example, the clothing areas **210** and **212** may be identified by determining a geometrical relationship from the faces **206** and **208**, respectively, and capturing a portion of an image that may relate to the clothing being worn by the respective people.

Image analysis of clothing may be used to compare two images to determine if those images were taken at the same event. Such a conclusion may be drawn when two images contain similar faces and the images additionally contain similar clothing textures or color histograms. Such an analysis may assume that the images represent the same event because the people in the images may be wearing the same clothes.

Additionally, a background area **214** may be analyzed for texture analysis, color histogram, or other analyses. Such results may be compared to other images to determine similarities and matches between the images.

In the image **204**, the faces **216** and **218** may be identified and captured. Because the size of the faces **216** and **218** may be relatively small, the clothing areas for the people of image **204** may not be performed, but a background area **220** may be identified and analyzed.

FIG. **3** is a flowchart illustration of an embodiment **300** showing a method for determining people rankings from an image collection. Embodiment **300** is an example of a method that may be performed by a comparison engine and ranking engine, such as comparison engine **162** and ranking engine **164** of embodiment **100**.

Other embodiments may use different sequencing, additional or fewer steps, and different nomenclature or terminology to accomplish similar functions. In some embodiments, various operations or set of operations may be performed in parallel with other operations, either in a synchronous or asynchronous manner. The steps selected here were chosen to illustrate some principles of operations in a simplified form.

Embodiment **300** may be an example of a method by which the number of occurrences of a person's face in a user's image collection may be used as an approximation of the user's interest in the person or the importance of the person to the user.

The faces within the images may be analyzed, compared, and grouped together into clusters. Based on the size of the clusters, the persons associated with the clusters may be ranked.

An image collection may be received in block **302**. The image collection may be pre-processed to identify faces and facial representations. An example of such a pre-processing method may be illustrated in embodiment **500** presented later in this specification.

Each image may be processed in block **304**. For each image in block **304**, if no faces exist in block **306**, the process may return to block **304** to process the next image. If one or more faces appear in the image in block **306**, each face may be separately processed in block **308**. For each face in block **308**, the face object and the associated image reference may be added to a list in block **310**. The image reference may be a pointer or other indicator for the image from which the face is taken.

After processing all of the images in block **304**, the resulting list may be sorted in block **312**.

In block **314**, the list may be analyzed to identify clusters based on a threshold value in block **314**. The clusters may define a group of facial representations that relate to a single person.

One mechanism to determine a cluster may be to consider a facial representation as a vector. The similarity between any two vectors may be considered a distance in the vector space. When multiple facial representations reflect many different images of the same person, the facial representation vectors may create clusters of vectors.

In many embodiments, a threshold may be used as part of a mechanism to determine whether or not a given facial representation is 'close' to another facial representation to be a match. The threshold may be determined in several different manners, and one such manner may be illustrated in embodiment **600**.

Each cluster may be analyzed in block **316**. For each cluster in block **316**, if any members of the cluster do not have tags or other associated metadata in block **318**, the process may return to block **316** to process another cluster.

If one or more of the members of the cluster in block **318** contains tags or other metadata, those tags may be applied to other cluster members in block **320**. In some cases, the user may be presented with a user interface device in block **322** where the user may approve or disapprove the tags. If the user approves the tags in block **324**, the tags may be applied to all members of the cluster in block **326**. If the user does not approve the tags in block **324**, the tags may not be applied to the members in block **328**.

In many social network applications, users may tag images with identifiers for specific people, for example. The process of blocks **316** through **328** may represent a method by which such tags may be applied to other images automatically. In some embodiments, the tags applied to the members of the cluster may be tags that relate to the person the cluster may represent. A simple example may be a tag that defines the person's name.

The clusters may be analyzed in block **330** to rank the clusters according to size. The ranking may reflect the relative importance of the people to the user. The cluster rankings may be used in block **332** to prioritize people in various applications.

For example, a newsfeed may include messages, status updates, or other information that relate to people in a user's social network. Those items relating to important people may be highlighted or presented in a manner that captures the user's attention. Other items concerning people who do not appear often in the user's image collection may be presented in a secondary or non-emphasized manner.

FIG. **4** is a flowchart illustration of an embodiment **400** showing a method for finding matching images based on facial analysis. Embodiment **400** is an example of a method that may be performed by a comparison engine, such as analysis engine **166** of embodiment **100**.

Other embodiments may use different sequencing, additional or fewer steps, and different nomenclature or terminology to accomplish similar functions. In some embodiments, various operations or set of operations may be performed in parallel with other operations, either in a synchronous or asynchronous manner. The steps selected here were chosen to illustrate some principles of operations in a simplified form.

Embodiment **400** illustrates an example of a method by which images from a second image collection may be compared to a first image collection to identify images in the second image collection that contain the same people as the first image collection.

A second image collection may be received in block **402**. The second image collection may be pre-processed in block **404**. One example of a method for pre-processing may be illustrated in embodiment **500** presented later in this specification.

Each image in the second image collection may be processed in block **406**. For each image in block **406**, if no faces are found in block **408**, the process may return to block **406** to process the next image.

If faces are found in block **408**, each face object may be processed in block **410**. For each face object in block **410**, a comparison may be made to the clusters of the first image collection in block **412** to find the closest match. If the match does not meet the threshold in block **414**, the process may return to block **410** to process the next face object. If the match is within the threshold in block **414**, the image is associated to the cluster in block **416**.

After processing all of the images in block **406**, the result may be a list of images from the second image collection that match clusters in the first image collection. The list may be ranked in block **418** according to the ranking that may be determined from the process of embodiment **300**, and presented to the user.

FIG. **5** is a flowchart illustration of an embodiment **500** showing a method for pre-processing images for facial analysis. Embodiment **500** is an example of a method that may be performed by an image pre-processor, such as the image pre-processor **128** of client **102** or image pre-processor **160** of a social network service **136** of embodiment **100**.

Other embodiments may use different sequencing, additional or fewer steps, and different nomenclature or terminology to accomplish similar functions. In some embodiments, various operations or set of operations may be performed in parallel with other operations, either in a synchronous or asynchronous manner. The steps selected here were chosen to illustrate some principles of operations in a simplified form.

The pre-processing of embodiment **500** may identify faces and create face vectors or some other numerical representation of a facial image for all images in an image collection.

An image file may be received in block **502** and may be scanned in block **504** to identify all faces.

If faces are found in block **506**, each face may be separately processed in block **508**. For each face in block **508**, the image may be cropped to the face in block **510** and a face object may be created from the cropped image in block **512**. A face vector may be created in block **514** which may be a numerical representation of the face image. The face vector and face object may be stored as metadata for the image in block **516**.

After all the faces are processed in block **508**, if another image is available in block **518**, the process may loop back to block **502**, otherwise the process may stop in block **520**.

FIG. **6** is a flowchart illustration of an embodiment **600** showing a method for setting a threshold value using a training set of images. Embodiment **600** is an example of a method that may gather example images from friends of a user and use those example images to set a threshold that may minimize false positive comparisons.

Other embodiments may use different sequencing, additional or fewer steps, and different nomenclature or terminology to accomplish similar functions. In some embodiments, various operations or set of operations may be performed in parallel with other operations, either in a synchronous or asynchronous manner. The steps selected here were chosen to illustrate some principles of operations in a simplified form.

Embodiment **600** may determine a threshold setting that may minimize false positive comparisons when comparing image collections. In many social network applications, a relatively high confidence threshold may be useful to minimize the likelihood of incorrectly identifying a match. When selecting photographs or video images from a second user's image collection to match a first user's image collection, an incorrect match may give a user a low confidence in the matching process. However, a missed match, where the match exists but the threshold does not permit the match to be detected, may not be as detrimental to the user's confidence.

The process of embodiment **600** gathers representative images from a user's friend's image collection to serve as a training set for comparisons. Facial comparisons may differ based on race, skin color, and other physical characteristics of those people associated with the user. The images selected may be from the user's friend's friends, and may reflect the probable physical characteristics of the people in the user's image collection.

The process of embodiment **600** may attempt to remove any people from the training set who may be likely to be in the user's image collection. This may be performed by examining any tags associated with the friend's images to ensure that the tags do not match the user's friends.

The user's friends may be identified in block **602**. The user's friends may be determined from relationships within the social network, as well as any other source. In some cases, a user may belong to several social networks, each with a different set of relationships. In such cases, as many of those relationships may be considered as possible.

Each of the user's friends may be processed in block **604**. For each friend in block **604**, each image in the friend's image collection is processed in block **606**. For each image in block **606**, the tags associated with the image may be identified in block **608**. If the tags are associated with friends of the user in block **610**, the image is not considered in block **610**. By excluding the friends of the user in block **610**, the training set may not include images that are likely to be matches for the user, but may include images of people having similar characteristics as people likely to be in the user's image collection.

If the tags indicate that the image may not be related to the user in block **610**, the image may be selected for the training set in block **612**. In many cases, the images selected for the training set may be a subset of all of the images in the friend's image collection. For example, a process may select one out of every 100 or 1000 candidate images as part of a training set. In some embodiments, a random selection may be made for the training set.

After selecting images to be in a training set in blocks **604** through **612**, a facial pre-processing may be performed on the training set in block **614**. The pre-processing may be similar to that of embodiment **500**.

The matching threshold may be set to a default value in block **616**.

Each image of the user's image collection may be processed in block **618** to set the threshold so that none of the images in the user's image collection match the training set. For each image in block **618**, if the image does not contain faces in block **620**, the process returns to block **618**.

When the image contains faces in block **620**, each face may be processed in block **622**. For each face in block **622**, the face object may be compared to face objects in the training set find the most similar face object in block **624**. If the similarity is less than the threshold in block **626**, the process may return to block **622**. If the similarity is greater than the threshold in block **626**, the threshold is adjusted in block **628** so that the threshold is lower than the similarity in block **628**.

After processing all of the images in the user's image collection in block **618**, the current threshold value may be stored in block **630** and used for subsequent comparisons.

FIG. **7** is a flowchart illustration of an embodiment **700** showing a method for event matching. Embodiment **700** is a simplified example of a method that may be performed by an analysis engine, such as the analysis engine **166** of embodiment **100**.

Other embodiments may use different sequencing, additional or fewer steps, and different nomenclature or terminology to accomplish similar functions. In some embodiments, various operations or set of operations may be performed in parallel with other operations, either in a synchronous or asynchronous manner. The steps selected here were chosen to illustrate some principles of operations in a simplified form.

Embodiment **700** is an example of a method that may be used to detect an event from metadata. The metadata may be metadata that may be derived from an image, such as from facial analysis or other image analysis. The metadata may also be metadata that is not derived from the image, such as a title, timestamp, or location information.

Embodiment **700** may infer an event from the intersection of the image collections of two users. Such an intersection may occur when both users attend the same event and both take images of the event. For example, two users may attend a birthday party or family gathering and take pictures of a family gathered for a meal. In another example, two users may attend a conference, sporting event, or other public event and may take images of the gathering. In some cases, the users may know about each other's attendance of the event and in other cases, the users may be unaware that the other person has attended.

In block **702**, an image collection may be received from a first user. In block **704**, an image collection may be received from a second user. In some embodiments, the information received may be just the metadata related to the images in the collection and not the actual images themselves.

The metadata from each image collection may be compared in block **706** to find matches. The matches may be based on image analysis, such as finding matching faces in images from two different collections. The matches may be based on metadata analysis, such as finding images that have timestamps, tags, location information, or other metadata that are matches.

In many cases, the matches may be determined with some level of tolerance or variance. The matches identified in block **706** may have a large amount of variance or tolerance, as each match may be further evaluated in later steps. The matching in block **706** may be a coarse or preliminary matching that may be further refined to identify a match with greater certainty.

The results of block **706** may be a pair of images from each collection. In some cases, the results may be a group of images from each collection that share similar metadata.

Each set of matched images may be compared in block **708**. For each set of matched images in block **708**, the metadata may be compared in block **710** to determine if an event can be inferred.

An event may be inferred based on several factors. Some factors may be weighted highly, while other factors may be of a secondary nature. The determination of whether a match indicates an event or not may be determined using various heuristics or formulas, and such heuristics or formulas may depend on the embodiment. For example, some embodiments may have extensive metadata available, while other embodiments may have fewer metadata parameters. Some embodiments may have sophisticated image analysis while other embodiments may have less sophisticated or even no image analysis.

A highly weighted factor may be in cases where the second user identifies the first user in one of the second user's images. Such metadata expressly identifies a link between the two image collections and indicates that both users were likely to be in the same place at the same time.

In some embodiments, users may tag images in their collections with persons from their social network. In such embodiments, a user may manually select an image and create a tag that identifies a friend in the image. Some such embodiments may allow the user to point to the face and attach the tag to a location on the image. Such tags may be considered reliable indicators and given higher weight than other metadata.

Other highly weighted factors may be very close proximity in space and time. Very close timestamps and physical location information may indicate that two users were at the same time and place. In some embodiments, an image may include a point from which an image was taken as well as a direction that a camera was facing when the image was taken. When such metadata are available, the overlap of the area covered by two images may be evidence of an event.

Some images may be tagged with various descriptors that are manually added by a user. For example, an image may be tagged with "Anna's Birthday Party" or "Tech Conference". When images from both image collections are similarly tagged, the tags may be good indicators of an event.

The matches may be analyzed using image analysis to identify common events. For example, a facial image match between images in both collections may be a good indicator of an event attended by and captured by both users. A facial image match may be further confirmed by similar background image areas and by clothing analysis of people associated with the matched faces.

When identifying a common event, different combinations of factors may be used in different situations and different embodiments. For example, an event may be determined by image analysis alone in some cases, even when the metadata do not correlate. For example, one user may purchase a camera device and may never correctly set the time and date in the camera, or may have the time set to a different time zone than the other user. In such a case, the timestamp metadata may be incorrect, but the image analysis may identify a common event.

In another example, the metadata may identify a common event even though the image analysis may not identify any common faces, background, or other similarities.

Different embodiments may have different thresholds for identifying an event. In a typical social network use of embodiment **700**, the analysis may be performed to automatically apply tags to images based on the events. In such an embodiment, a higher degree of certainty may be desired so that incorrect tags are not introduced into the image collection as noise. In another use, the matching may be used to identify possible events that a user may manually examine to determine if an event actually did occur. In such a use, the threshold to determine an event may have a much lower degree of certainty than in the other use case.

If an event is not determined in block **712**, the process may return to block **708** to process another match.

If an event is identified in block **712**, all images associated with the event may be identified in block **714**. A metadata tag may be defined for the event in block **716**, and the tag may be applied to the images in block **718**.

The images associated with the event may be determined by identifying images that are related to or share common metadata or other features with the matched images. For example, two images may be matched, one from either image collection. Once those images are matched, any related images to the matched images within their respective collections may be identified in block **714**.

The metadata tag in block **716** may be generated by scanning the related images to determine if an event tag is associated with any of the related images. For example, one of the images that was gathered in block **714** may be tagged with an event tag, such as "Anna's Birthday". That tag may then be applied to all of the related images in block **718**.

In some embodiments, the event tag of block **716** may be an automatically generated event tag that may identify how the match was determined. For example, a match that was determined by common metadata having time and location information may have a tag that includes "Jerusalem, 22 Feb. 2010". Each embodiment may have different mechanisms for determining a tag.

In some embodiments, the tag applied in block **718** may not be visible to a user. Such a tag may be used by a social network to link different image collections together to provide enhanced search or browsing capabilities and may not expose the tag to the user for viewing or modification.

FIG. **8** is a flowchart illustration of an embodiment **800** showing a method for event matching between a user's image collection and those of the user's friends. Embodiment **800** is a simplified example of a use scenario for the event matching method described in embodiment **700**.

Other embodiments may use different sequencing, additional or fewer steps, and different nomenclature or terminology to accomplish similar functions. In some embodiments, various operations or set of operations may be performed in parallel with other operations, either in a synchronous or asynchronous manner. The steps selected here were chosen to illustrate some principles of operations in a simplified form.

Embodiment **800** compares a user's image collection to those of the user's friends. The comparison may identify events that were shared by the two users and may identify images in the friend's image collection that the first user may like to add to his or her image collection.

Embodiment **800** may be a powerful tool for linking two image collections together in a social network. In some uses, the two users may know that they have attended the same event and may wish to share their images with each other. In other uses, the users may not remember attending the same event or may not realize that both were there. The method of embodiment **800** may enhance the users' interaction by identifying the intersections in their lives and allowing them to share the event through their images.

In block **802**, a user's image collection may be received. The user's friends may be identified in block **804** and each friend may be processed in block **806**. For each friend in block **806**, event matching may be performed in block **808** between the user and the user's friend to identify common events. The event matching may be performed in a similar manner as described in embodiment **700**.

Each new event that was found in block **808** may be analyzed in block **810**. For each new event in block **810**, images may be selected from the friend's image collection in block **812** that match the event. Any metadata from the selected images from the friend's image collection may be identified in block **814** and applied to the user's images that are related to the event in block **816**.

The operations of block **814** and **816** may propagate tags and other metadata from the friend's image collection to the user's image collection. In some embodiments, a user may be given an option to approve or disapprove the tagging. The tags and other metadata may enrich the user's image collection by applying useful tags automatically or semi-automatically.

The friend's images may be presented to the user in block **818** and may be grouped by event. An example of a user interface may be illustrated in embodiment **1000** presented later in this specification.

After processing each event in block **810**, the user may browse the friend's images and select one or more of the friend's images in block **820**. The selected images may be added to the user's image collection in block **822**.

FIG. **9** is a flowchart illustration of an embodiment **900** showing a method for event matching between pairs of a user's friends. Embodiment **900** is a simplified example of a use scenario for the event matching method described in embodiment **700**.

Other embodiments may use different sequencing, additional or fewer steps, and different nomenclature or terminology to accomplish similar functions. In some embodiments, various operations or set of operations may be performed in parallel with other operations, either in a synchronous or asynchronous manner. The steps selected here were chosen to illustrate some principles of operations in a simplified form.

Embodiment **900** compares two of a user's friend's image collections to identify events that can be inferred from two of the user's friends. Images from the inferred events may be presented to the user and the user may add those images to the user's image collection.

Embodiment **900** may be useful in a social network scenario where a user may or may not be present at an event and may wish to view images of the event and may add some of those images to the user's image collection. For example, grandparents who are unable to attend a grandchild's party may wish to see images of the party. The party may be inferred by analyzing image collections from two or more people that attended the party. By inferring the event from analysis of the image collections, all of the relevant images to the event may be gathered and presented to the grandparents for them to enjoy.

Embodiment **900** operates in a similar manner as embodiment **800**, however the image collections used for the event matching may be pairs of collections from the user's friends as opposed to comparing a user's collections to those of his or her friends.

A user's friends may be identified in block **902** and placed in a list. The friends may be identified through a social network. Each friend may be processed in block **904**. For each friend in block **904**, each remaining friend on the list of friends may be analyzed in block **906**. The remaining friends are those friends for which an image collection has not been processed. For each remaining friend in block **906**, an event matching process may be performed between the two friend's image collections in block **908** to identify common events. The process of blocks **904** and **906** may be arranged so that each pair of friends may be processed to identify common events.

Each common event may be processed in block **910**. For each common event in block **910**, some embodiments may include verification in block **912** to determine if the user could have been present.

The verification of block **912** may be used to prevent showing an event to which the user was not invited. For example, two of a user's friends may get together for a night on the town and may not invite the user. To prevent the user from being insulted, some embodiments may include verification such as block **912** to prevent the user from finding out that the event occurred. In other embodiments, such as with the example with the grandparents above, the verification of block **912** may not be included or may be overridden.

In some social networks, a user may be able to select whether or not to share the events with other users, and may be able to select which users may view their common events and which users may not.

In block **914**, images from the friend's image collection may be selected from the common event and presented to the user in block **916** grouped by the event. After processing all the common events in block **910**, the user may browse and select images in block **918** and may add selected images to the user's collection in block **920**.

FIG. **10** is a diagram illustration of an example embodiment **1000** showing a user interface with results from an event matching analysis. Embodiment **1000** is a simplified example of a user interface that may be used to present the results of an event matching analysis to a user, such as the event matching analysis of embodiments **800** or **900**.

A user interface **1002** may display the results of an event matching process. In the user interface **1002**, results from three events are illustrated. Event **1004** may have a tag "Birthday Party", event **1006** may have a tag "Holiday at Beach" and event **1008** may have a tag "Skiing Vacation". The various tags may be identified from tags defined from the image collections of the friends. In some cases, the tags may be determined from the user's images that match the detected events.

Each event may be presented with a source for the images. For example, event **1004** may have an image source **1010** of "From Mom's and Joe's Collection". Event **1006** may have an image source **1012** of "From Joe's Collection", and event **1008** may have an image source **1014** of "From Lora's Collection". The image sources may be created using the user's labels for the user's friends.

The user interface **1002** may also include various metadata relating to the event. For example, event **1004** may be presented with metadata **1016** that indicates which of the user's friends were determined to be at the event. Similarly, event **1006** and **1008** may have metadata **1018** and **1020**, respectively.

Each event may have a selection of images presented. Event **1004** is shown with images **1022**, **1024**, and **1026**. Event **1006** is shown with images **1028** and **1030**, and event **1008** is shown with image **1032**. Next to each image may be a button or other mechanism by which a user may select one or more images to add to the user's image collection.

The user interface of embodiment **1000** is merely one example of some of the components that may be presented to a user as a result of image matching analysis, such as event matching. The user interface may be a mechanism by which a user may browse the results of a match analysis and perform operations on the results.

FIG. **11** is a flowchart illustration of an embodiment **1100** showing a method for creating clusters that may be used for matching images. Embodiment **1100** is a simplified example of one method by which clusters may be created by analyzing a single image collection and grouping images. The clusters may be used in image comparison analyses and metadata comparison analyses.

Other embodiments may use different sequencing, additional or fewer steps, and different nomenclature or terminology to accomplish similar functions. In some embodiments, various operations or set of operations may be performed in parallel with other operations, either in a synchronous or asynchronous manner. The steps selected here were chosen to illustrate some principles of operations in a simplified form.

Embodiment **1100** may illustrate a simplified method for creating clusters of images. A cluster may be a group of images that may share common features, and may be useful in grouping faces as well as grouping images as a whole.

A cluster may be created by identifying a vector that represents the image and by grouping the vectors together. A cluster may have a centroid and radius, and numerical comparisons may be made between an image and the cluster to determine a 'distance' between the image and cluster to determine a match.

An image collection may be received in block **1102** and each image in the image collection may be analyzed in block **1104**. In embodiments where facial recognition is used, the images may be face objects that may contain only the facial features of people cropped from larger images. In such embodiments, the analysis may create a vector that represents the face object. In other embodiments, the entire image may be analyzed to create an image vector.

The image may be analyzed in block **1106** to create an image vector. The image vector may contain numerical representations of various elements of the image, including facial image analysis, clothing analysis, background image analysis, and texture analysis.

In some embodiments, the analysis of block **1106** may create several image vectors. For example, an image having two faces may be represented with two image vectors representing the faces, two image vectors representing the clothing of the two people, and one or more vectors representing background images or various textures in the image.

After each image is analyzed in block **1104**, the images may be grouped together in block **1108**. The grouping may be using both metadata grouping and image analysis grouping. One mechanism for grouping may be to group images together on independent or orthogonal grouping axes for each metadata category or type of image analysis. For example, one grouping axis may be established for facial image analysis. On such an axis, all facial image representations or vectors may be grouped. Separately, each image may be grouped according to different metadata, such as timestamp or location.

Within each axis, clusters may be identified in block **1110**. The definition of a cluster may be controlled using a threshold that may limit clusters to tight groupings of images. The clusters may be used to represent actual matches of images with a high degree of certainty so that other operations, such as image comparisons and ranking may have a high degree of certainty.

Each axis on which the images are grouped may have a different threshold for identifying a cluster. For example, facial image matching may have a relatively tight threshold so that only matches with very high degree of similarity may be considered a cluster. Conversely, images that are matched by background image analysis may have a less restrictive threshold so that a wider range of images may be grouped.

Each cluster may have a centroid and radius calculated in block **1112**. The centroid and radius may be used to determine matches when other images are compared to the image collection. The clusters as well as the centroid and radius may be stored in block **1114**.

FIG. **12** is a flowchart illustration of an embodiment **1200** showing a method for matching images using centroid and radius analysis of clusters. Embodiment **1200** may illustrate one method by which the analyzed images of embodiment **1100** may be used to identify matches between a user's image collection and a friend's image collection, then to select the most appropriate or best match to display to the user.

Other embodiments may use different sequencing, additional or fewer steps, and different nomenclature or terminology to accomplish similar functions. In some embodiments, various operations or set of operations may be performed in parallel with other operations, either in a synchronous or asynchronous manner. The steps selected here were chosen to illustrate some principles of operations in a simplified form.

A user's image collection may be received in block **1202**, and a friend's image collection may be received in block **1204**. The user's friend's image collection may be pre-processed in block **1205**. An example of a pre-processing method may be embodiment **500**. The pre-processing of embodiment **500** may apply to facial image analysis, and may be extended to background image analysis, texture analysis, color histogram analysis, clothing analysis, and other image analysis pre-processing.

The pre-processing of block **1205** may correspond to any analysis performed prior to clustering of the user's image collection.

Each image in the friend's image collection may be analyzed in block **1206**. For each image in block **1206**, each cluster associated with the user's image collection may be analyzed in block **1208**.

As described in embodiment **1100**, each image collection may contain multiple clusters in multiple orthogonal axes. Each cluster may represent an important aspect or element of the user's image collection, and those aspects may be used to compare with the images from the friend's image collection.

For each cluster in block **1208**, a distance from the analyzed image to the nearest cluster may be determined in block **1210**. If the distance is within a centroid matching threshold in block **1212**, the image may be associated with the cluster in block **1218**.

If the distance is not within the centroid matching threshold in block **1212**, a distance to the nearest neighbor may be determined in block **1214**. If the distance to the nearest neighbor is not within the neighbor threshold in block **1216**, no match is determined.

The nearest neighbor may be an image that is within the cluster. The nearest neighbor evaluation may identify images that fall outside of the cluster but very near one of the images that has been grouped with the cluster. In a typical embodiment, the neighbor threshold may be small when compared to the centroid threshold.

After analyzing all of the images in the friend's image collection in block **1206**, the friend's images may be selected for presentation to the user.

The user's clusters may be ranked by size in block **1220**. The ranking may be used as a proxy for importance to the user. Each cluster may be evaluated in block **1222**. For each cluster in block **1222**, the matched images may be compared to the clusters to find the closest image to a neighbor in block **1224** and to a cluster centroid in block **1226**. The best match may be determined in block **1228** and added to a user interface display in block **1230**.

The process of blocks **1220** through **1230** may identify those matches that may be the most relevant to the user as well as the most likely to be good matches. The relevance may be determined by the ranking of the clusters derived from the user's image collection. The best matches may be those images that are nearest to the centroid of a cluster or very near to another image, which may be represented by the nearest neighbor.

Image matching may be prone to noise and many image matching algorithms may result in false positive results, where an image is incorrectly matched. In a social networking application that has image matching, user satisfaction with the matching mechanism may be higher when the user is presented with quality matches.

The process of blocks **1220** through **1230** may select the best match from the available matches to present to the user. Such a process may select a representative match for each cluster and present each match to the user, enabling the user to view a wide variety of matches.

After selecting the images, the images may be presented to the user organized by cluster in block **1232**. The user may browse and select images in block **1234** and may add the images to the user collection in block **1236**.

In some embodiments, the user may be able to drill down into the matches for a particular cluster to view additional matches. In such a case, the process of blocks **1220** through

1230 may be used to organized and select the most appropriate images from the subset of images matching the particular cluster.

The foregoing description of the subject matter has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the subject matter to the precise form disclosed, and other modifications and variations may be possible in light of the above teachings. The embodiment was chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and various modifications as are suited to the particular use contemplated. It is intended that the appended claims be construed to include other alternative embodiments except insofar as limited by the prior art.

What is claimed is:

1. A method comprising:

by the at least one computer processing device:

receiving image metadata from an image collection that is associated with a user, the image metadata comprising processed face objects from images of the image collection;

analyzing the image metadata to identify similar face objects, the similar face objects having one or more matching criteria with respect to a threshold;

grouping the similar face objects into clusters, wherein, within the image collection that is associated with the user, individual clusters have different numbers of occurrences of the similar face objects;

determining person identities associated with the individual clusters; and

ranking the person identities based on the different numbers of occurrences of the similar face objects within the image collection that is associated with the user, the person identities including a first person identity of a first person other than the user and a second person identity of a second person other than the user, wherein the first person identity is associated with a first individual cluster having a first number of occurrences of face objects of the first person and the second person identity is associated with a second individual cluster having a second number of occurrences of face objects of the second person, wherein the first number of occurrences is greater than the second number of occurrences and the first person identity is ranked higher than the second person identity.

2. The method of claim **1**, further comprising:

by the at least one computer processing device:

prioritizing, for the user, first messages relating to the first person over second messages relating to the second person based on the ranking.

3. The method of claim **2**, wherein the image collection is associated with a social network account of the user for a social networking application and the prioritizing comprises prioritizing the first messages over the second messages within the social networking application.

4. The method of claim **3**, wherein the prioritizing comprises prioritizing the first messages over the second messages within a newsfeed of the social networking application.

5. The method of claim **1**, further comprising:

by the at least one computer processing device:

emphasizing first items related to the first person identity; and

not emphasizing second items related to the second person identity.

6. The method of claim **1**, wherein:

the user has an associated social networking account that includes the image collection, and

the person identities are ranked according to at least the different numbers of occurrences of the similar face objects within the image collection of the social networking account.

7. A system comprising:

at least one hardware processor; and

at least one memory or non-volatile storage media storing computer-readable instructions which, when executed by the at least one hardware processor, cause the at least one hardware processor to:

obtain image metadata for images of an image collection that is associated with a user, the image metadata comprising processed face objects from the images of the image collection;

analyze the image metadata to identify similar face objects, using one or more matching criteria;

group the similar face objects into clusters, wherein, within the image collection that is associated with the user, individual clusters having different sizes based on numbers of occurrences of the similar face objects that are associated with different people; and

rank the different people based on the different sizes of the individual clusters, the different people including a first person other than the user and a second person other than the user, wherein the first person is associated with a first individual cluster having a first number of occurrences of face objects of the first person and the second person is associated with a second individual cluster having a second number of occurrences of face objects of the second person, wherein the first number of occurrences is greater than the second number of occurrences and the first person is ranked higher than the second person.

8. The system of claim **7**, wherein the computer-readable instructions further cause the at least one hardware processor to:

produce the image metadata by:

analyzing individual images to identify faces within the individual images,

processing the faces to determine face vectors for the faces, and

storing the face vectors in the image metadata.

9. The system of claim **7**, wherein the image collection is associated with a social network account of the user for a social networking application.

10. The system of claim **9**, wherein the computer-readable instructions further cause the at least one hardware processor to:

prioritize, for the user, first status updates in the social networking application relating to the first person over second status updates in the social networking application relating to the second person.

11. The system of claim **10**, wherein the computer-readable instructions further cause the at least one hardware processor to:

prioritize the first status updates over the second status updates in a social networking newsfeed of the social networking application.

12. The system of claim **7**, wherein the computer-readable instructions further cause the at least one hardware processor to:

analyze other images of another image collection of another user; and

rank first other images of the another image collection that include the first person relatively higher than second other images of the another image collection that include the second person.

13. The system of claim **7**, wherein the computer-readable instructions further cause the at least one hardware processor to:

analyze other images of another image collection of another user to determine a confidence threshold; and

use the confidence threshold to identify the similar face objects.

14. The system of claim **7**, wherein the computer-readable instructions further cause the at least one hardware processor to:

incrementally update the ranking as the different sizes of the individual clusters change responsive to new images being added to the image collection.

15. One or more computer-readable memory devices or storage devices having instructions stored thereon that, when executed by a computing device, cause the computing device to perform acts comprising:

obtaining image metadata for images of an image collection that is associated with a user, the image metadata comprising processed face objects from the images of the image collection;

analyzing the image metadata to identify different clusters of images in the image collection that is associated with the user, the different clusters representing different people and having different associated cluster sizes in the image collection of the user, wherein the different clusters of images including at least a first cluster of images representing a first person other than the user and a second cluster of images representing a second person other than the user, wherein the first cluster has a first cluster size and the second cluster has a second cluster size; and

ranking the different people based on the different associated cluster sizes,

wherein the different associated cluster sizes are based on corresponding numbers of occurrences of corresponding face objects of the different people in the image collection that is associated with the user, the first cluster having a first number of corresponding occurrences of first face objects of the first person other than the user and the second cluster having a second number of corresponding occurrences of face objects of the second person other than the user.

16. The one or more computer-readable memory devices or storage devices of claim **15**, wherein the first cluster size is greater than the second cluster size, the acts further comprising:

highlighting at least one item associated with the first person and not another item associated with the second person based on the first cluster size being greater than the second cluster size.

17. The one or more computer-readable memory devices or storage devices of claim **16**, wherein analyzing the image metadata comprises identifying vectors representing the images and performing numerical comparisons between the images and the clusters.

18. The one or more computer-readable memory devices or storage devices of claim **17**, the acts further comprising:

cropping the face objects from the images before identifying the vectors and performing the numerical comparisons.

19. The one or more computer-readable memory devices or storage devices of claim **17**, the acts further comprising:

calculating centroids and radii of the different clusters; and

using the centroids and the radii to determine matches to individual clusters when new images are added to the image collection.

20. The one or more computer-readable memory devices or storage devices of claim **17**, the acts further comprising:

calculating centroids and radii of the different clusters;

evaluating another image collection of a friend of the user in a social network by determining, using the centroids and radii, whether other images in the another image collection fall within the individual clusters; and

based on the evaluating, selecting individual other images from the another image collection to present to the user.

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